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EARLY AMBULATION FOLLOWING SECTION OF  
THE ANTERIOR ABDOMINAL WALL

AN ANALYSIS OF FOUR HUNDRED AND TWENTY-SIX PERSONALLY CONDUCTED CASES

HARRY NELSON, M.D.

NEW ORLEANS

Some years ago, on the basis of two more or

less accidental observations, I began to question whether the time-honored practice of absolute

rest in bed following an abdominal section was really in the best interests of the patient. The

first observation concerned the excellent healing of wounds and the low incidence of postoperative

complications in children, in spite of the fact that they are never restrained after operation

and that their movements, from the moment of their recovery from anesthesia, sometimes ap-

proach violence. The second had to do with the similarly excellent healing of wounds in

animals submitted to abdominal section for various experimental procedures; in most in-

stances complications of the wounds were notably absent, and I have observed and, on inquiry, could learn of no instance of disruption of a

wound under these circumstances.

As the result of these observations I undertook a review of the literature dealing with early ris-

ing after operation, while at the same time I pro-

ceeded to put the plan into cautious practice in my personal cases. I am now able to report a

series of 429 operations through 426 incisions of the anterior abdominal wall in 423 patients,

for whom, as will be pointed out, the incidence of postoperative complications was considerably

lower than might be expected in a similar series in which the subjects were not ambulated, while

at the same time no harm accrued to the patients, whose convalescence was actually smoother and

more rapid than that under the old practice of prolonged rest in bed.

REVIEW OF THE LITERATURE

The literature of early postoperative walking was extensively reviewed by Newburger<sup>1</sup> in 1943, and repetition of his long bibliography would not be justified here. A few of the more

From the Independent Surgical Service of Charity Hospital of Louisiana at New Orleans.

I. Newburger, B.: Early Postoperative Walking: Collective Review, *Surgery* 14:142-154 (July) 1943.

1

mentioned. Ries,<sup>2</sup> in 1899, seems to have been the first to state that "the period for which it was advisable to confine such cases [surgical patients] to bed could be counted by hours instead of days." His

tenacity was originally limited to patients who had undergone "vaginal celiotomy" but was soon

extended to patients who had been subjected to "ventral celiotomy," the rationale being that

since it is impossible to keep other parts of the body, such as the tongue, the chest or the veins,

at absolute rest after a surgical operation, there is no reason why the abdominal wall should be kept

at rest either. He declared himself thoroughly satisfied with the results of early ambulation,

which included a striking absence of ileus and of loss of muscle tone, as well as improvement in

the happiness of the patient; however, he sup-

plied no statistics.

In the foreign literature (cited by Newburger), the discussion seems to have been opened by

Rehn, in 1902, with the statement that immobili-

zation after operation, regardless of its possible desirability from the standpoint of the healing of

the wound, is detrimental to the patient as a unit. This consideration was the basis for Henle's

"promenade in bed" (*Spaziergang im Bett*), which was not, however, reported until 1908,

in which year Kummell recommended the prac-

tice of early rising after operation.

Boldt,<sup>3</sup> in 1907, supplemented an apparently informal report on the subject two years earlier

with a statistical study of 384 personal cases, in-

cluding cases in which "complicated" operations on the intestinal tract were done. Many of the

patients had been permitted out of bed within twelve hours after operation. The only compli-

cations in the series were 2 instances of mild

2. Ries, E.: Some Radical Changes in the After-Treatment of Celiotomy Cases, *J. A. M. A.* 33:454-456 (Aug. 19) 1899.

3. Boldt, H. J.: The Management of Laparotomy Patients and Their Modified After Treatment, New York M. J. 85:145-153 (Jan. 26) 1907.



complications, develop well within this limit. For many reasons we do not advocate permitting patients to walk from the operating room after abdominal section, as advised by certain Continental writers.

No patient is forced to practice early rising who is unwilling to attempt it. We merely present our recommendations, supported by results, to eligible patients and permit them to get up or remain in bed, as they choose. Surprisingly few refuse early ambulation. Sometimes, even before the plan is presented to them, patients request permission to attempt it because they have observed good results in their associates in the ward. Some who at first refuse to leave their beds later do so when they observe the smoothness of convalescence in those who practice the plan.

Early ambulation is not carried out in the presence of any of the following contraindications:

1. Failure to observe any of the prerequisites of optimum healing of wound, including failure to carry out the tensels of Halsted as to the closure of a wound, the use of suture materials other than wire or cotton and the existence of deficiencies of vitamins and hypoproteinaemia.
2. Conditions for which absolute rest in bed is demanded, such as shock peritonitis, active hemorrhage, cardiac failure, pneumonitis and impending or actual thyroid crisis.
3. Potential or actual complications of the wound, including gross contamination, infection, hemorrhage and dehiscence.

4. Pregnancy in which abortion is feared. Pregnancy per se is not a contraindication.

5. Extreme debility, for which ambulation is deferred until there is some restoration of strength and muscle tone, as a result of sitting up.
6. Second stage of a thoracolumbar sympathetic, after which the patient, because of sudden alterations in the vascular system, cannot immediately tolerate the upright position.
7. Lack of adequate and intelligent nursing supervision. It is true that in one sense early ambulation reduces the amount of nursing care necessary. On the other hand, it is important that the nursing supervision be adequate to insure that the patient obeys instructions as to when and how long he shall walk.

In my opinion only cotton and wire are suitable for use in these circumstances, because they alone combine most of the desiderata of ideal suture material. Although others have employed suture material in operations after early ambulation was practiced, its use is associated with a high degree of irritability of tissues and a high incidence of contamination of wounds and, like nylon,

it does not have the ability to retain square knots consistently. Wounds closed with it, as well as those closed with silk, become dangerously weak on the third and fourth days respectively, as pointed out by Localio and his associates<sup>7</sup> (chart) and do not approximate even the minimum strength of wounds closed with cotton until the fifth postoperative day. Nylon, while approaching cotton in its ability to maintain tensile strength in the wounds during the lag period, may, as pointed out by Letihaner, be responsible for the development of granulomas as late as ten months after operation. On the other hand, cotton causes minimal irritability of tissues, is associated with a minimal incidence of contamination of wounds and holds square knots reliably, and the tensile strength of a wound sutured with it (chart) at no time drops below 75 per cent of the strength of the intact abdominal wall.

#### OUTLINE OF PLAN OF EARLY AMBULATION

As soon as the patient has fully recovered from the effects of anesthesia (in my opinion the particular anesthetic agent used is not significant), the bed is sharply tilted, so that the head is elevated. After this position has been maintained for a time, the bed is leveled and the patient assumes a sitting position on the side of the bed, with the feet resting on a chair. In this position he breathes deeply and coughs frequently. He then lies down, and the head of the bed is again sharply elevated. After a second period of rest he is assisted to stand and is conducted to the bathroom, where the bladder is practically always emptied without difficulty. If his condition is good, and if he wishes, he sits up in a chair for a time before returning to bed. The rapidity with which these different steps are carried out varies with the individual case, but ordinarily there is no great delay between them.

After the pain of the initial ambulation patients seldom complain again of even significant discomfort. Those who are oversensitive to the pain of the first rising or who are unduly apprehensive are made to practice sitting at the edge of the bed, with intervals of rest between each attempt, until they are strong enough and willing to walk to the bathroom. After the initial ambulation all patients are allowed to rise as often as they please, to go to the bathroom, which they invariably prefer to the use of the bedpan, to fetch drinks and to sit on the sun porch.

7. Localio, S. A.; Casale, W., and Hinton, J. W.: Wound Healing—Experimental and Statistical Study: IV. Results, Surg., Gynec. & Obst. 77:376-388 (Oct.) 1943.





to note this fact and wrote a later order for the usual routine to be carried out. The confusion was discovered after the first ambulation, and the patient was thereafter kept in bed with absolute rest. Three days later, however, the catgut-closed portion of the wound remained intact. Secondary closure was done with wire. On the fourth postoperative day the patient showed signs pointing to a cerebrovascular accident, and death occurred ten days after operation and four days after secondary closure. The clinical diagnosis of cerebral thrombosis and pulmonary congestion was confirmed at autopsy, which revealed the wound to be in good condition and the peritoneal cavity free from infection.

Two additional instances of partial separation of the wound occurred after operations in this series, in 1 of which, as in the case just described, early ambulation was not ordered. The patient had been submitted to incisional hernioplasty, for which catgut had been used. Entirely without authorization she left her bed on the second postoperative day, and three days later a small separation of the wound was observed. It was closed with wire, and convalescence thereafter was uneventful. The third case of dehiscence represented a failure on the part of the surgeon as well as on the part of the wound. The patient, a 35 year old man, had been stabbed in the abdomen and had lost a large quantity of blood. Exploration through an upper right rectus incision revealed no visceral injury. Through an inexcusable oversight no blood or plasma was administered and an order for early ambulation was written. The wound gaped slightly on the fourth postoperative day and was reapproximated with wire. At the time of writing, eighteen months after the operation, there was no evidence of hernia.

Other complications observed in the hospital included: 8 instances of infection of the wound and 1 instance of stitch abscess; 1 instance of pneumonia, in a case of carcinoma of the esophagus, with mediastinal extension and severe bronchorea; 1 instance each of atelectasis, pneumonia, edema of the scrotum, edema of the spermatic cord and abortion. The abortion was suspected to have been self induced, since the patient had made it clear that she did not wish the child, but no proof could be obtained.

It will be noted that there is a striking absence of such complications as embolism, phlebitis, peritonitis and infection of the urinary tract, a certain number of which, by the law of averages, might be expected to occur in a series of this size.

per mission twelve months after operation to be a bicycle; when it had been given, he stated at he had been doing so for some time and greatly desired official sanction.

The 426 abdominal incisions included 286 transverse incisions, of which 9 were high, 9 median and 268 low; 64 vertical incisions, of which were high, 7 median and 52 low, and 76 oblique incisions, of which 3 were high and 73 low. The large proportion of transverse incisions in this series of operations should be noted. Tension in is type of wound is minimal, and its other advantages have recently been pointed out by Rees and Collier.<sup>8</sup>

*Early Ambulation After Four Hundred and Twenty-Nine Intraabdominal Surgical Procedures Through Four Hundred and Twenty-Six Incisions of the Anterior Abdominal Wall*

Operation	Number of Operations
Pendectomy (for disease limited to appendix).....	217
Hernioplasty.....	59
Inguinal.....	3
Femoral.....	12
Umbilical.....	5
Incisional.....	2
Jejunostomy.....	2
Partial gastrectomy.....	1
Astrostomy.....	2
Gastrostomy.....	1
Major operations.....	1
Resection of left half of colon.....	1
First stage Lyley resection of rectum.....	2
Indefinite laparotomy.....	2
Reduction of volvulus of sigmoid.....	1
Closure of colostomy.....	4
Operations on the biliary tract and the liver.....	3
Cholecystectomy.....	1
Cholecystostomy.....	1
Resection of anomalous bile duct.....	1
Hepatorrhaphy.....	1
Cellulaneous operations.....	4
Exploration.....	1
Resection of diaphragm.....	1
Repair of diaphragm.....	1
Repair of diaphragm.....	1
Complete hysterectomy, bilateral salpingo-oophorectomy.....	1
Secondary closure of wound.....	2

*Results.*—Although the single death in this series was from cerebral thrombosis, which obviously is not related to early rising, an unfortunate series of errors occurred after this particular operation, in which a combined abdominal-uterine resection was done on a 66 year old woman. The supply of sterile cotton was inadequate, and the lower half of the wound, exterior to the peritoneum, had to be closed with catgut. For this reason the usual order for early postoperative ambulation was omitted from the postoperative orders, but the resident for the ward, who had not been present at the operation, failed to observe this omission.

Rees, V. L., and Collier, F. A.: *Anatomic and Clinical Study of the Transverse Abdominal Incision*, Arch. Surg. 47:136-146 (Aug.) 1943.

Of the patients reported here, 301 (71 per cent) have been observed after operation in the New Orleans Charity Hospital of Louisiana at Orleans for periods up to two years. Most of the remainder have been heard from by letter or are known to have been accepted for full military duty in the condition in which they presented themselves. Since almost 90 per cent of all delayed postoperative complications are observed within three months after operation and most of the remaining 10 per cent within twelve months, it may be assumed that the complications observed during this two year period represent practically all that are likely to occur in these patients. They included: 2 small incisional hernias, 1 following closure of a colostomy opening, improperly excised by me, and the other in an infected lower right rectus incision, made for exploration for a stab wound (hernioplasty has been carried out in each case, but too recently to state the final results); 1 recurrent hernia, following incisional hernioplasty (repair was difficult because of the widespread destruction of the anterior rectus sheath by previous infection, and it was later determined from the operator that only the posterior rectus sheath and the superficial fascial layer had been approximated in the course of the repair); 2 painful scars, both relieved by a local injection of procaine hydrochloride, 2 infections of wounds; 2 stitch abscesses and 1 extrusion of a suture in a clean wound; 1 instance of edema of the spermatic cord and 1 instance of edema of the scrotum.

# COMMENT

As this and other reports indicate, the chief benefit derived from the practice of early ambulation is the reduction of postoperative complications, for which, as Rehn (cited by Newburger) aptly stated, the bed is a veritable breeding place. Since the majority of the deaths which follow surgical operations are the result of postoperative complications, it follows that the practice of early rising can fairly be said to play a part in the reduction of postoperative mortality. Two groups of postoperative complications, pulmonary and vascular, are particularly important. Opinions may differ as to their pathogenesis, but there is no difference of opinion as to their seriousness and as to the relative or absolute ineffectiveness of all measures which have been proposed to reduce their incidence and severity. This is not the place to enter into a detailed discussion of the pathogenesis of postoperative atelectasis and pneumonia, but certain pertinent facts may be stated (in greatly over-

The pathogenesis of thrombosis and embolism (also stated in a greatly oversimplified form) is about as follows: Clotting is a result of chemical alterations of the blood following operation and anesthesia, combined with a deceleration of the rate of venous flow. This deceleration is a direct result of decreased muscular activity and of general loss of tone of the vascular system, as a consequence of recumbency. Ample statistical evidence exists as to the value of early rising in the prevention of thrombosis and embolism. At the Essinger University Clinic, for instance (cited by Ochshner and DeBakey<sup>11</sup>), the incidence of thrombosis and fatal

9. Kaltreider, N. L., and McCann, W. S.: Respiratory Response During Exercise in Pulmonary Fibrosis and Emphysema, *J. Clin. Investigation* 16:23-40 (Jan.) 1937.
10. Barman, J. M.; Consolazio, F., and Moretz, M. F.: Relation Between Pulmonary Ventilation and Oxygen Consumption After Exercise, *Am. J. Physiology* 138:16-19 (Dec.) 1942.
11. Ochshner, A., and DeBakey, M.: Therapeutic Considerations of Thrombophlebitis and Phlebotrombosis (Shattuck Lecture), *New England J. Med.* 225:207-227 (Aug. 7) 1941.

not be overlooked, nor must the more rapid convalescence and the briefer period of hospitalization, which result in economic saving to both patient and hospital. The medical and nursing staffs attached to our wards have been impressed with the smooth convalescence of patients who are ambulated early and have commented particularly on the infrequent incidence of catheterization, as compared with the usual postoperative incidence.

The low incidence of postoperative complications in patients ambulated early is the obvious answer to possible charges of malpractice. The question was first raised by Boldt in 1907 and was answered by him then as satisfactorily as it could be answered today: To prove that this practice is responsible for such postoperative complications as occur (he spoke particularly of thrombosis and embolism), it would be necessary to prove that these complications do not occur in patients kept in bed for conventional periods of time.

The same author's devastating observation that those who oppose the plan of early postoperative ambulation are generally those who have had no experience with it is also still valid. Furthermore, it is fair to emphasize that poor results obtained by those who ignore the definite criteria established for early ambulation do not constitute a valid reason for condemning the whole plan.

#### SUMMARY AND CONCLUSIONS

Although early ambulation following intra-abdominal operations was first recommended in 1899, the practice has never been generally followed, and most of the few critically analyzed series have been published within the last two or three years.

An analysis of this series of 429 operations through 426 incisions of the anterior abdominal wall after which ambulation was practiced within seventy-two hours shows that the majority of the patients walked on the day of operation or within the first twenty-four hours.

The incidence of immediate and delayed complications in this series was minimal. Of the 3 partial disruptions of a wound 2 occurred in patients whose wounds had been closed with catgut and for whom early ambulation had not been authorized. The third was due to an error on the part of the surgeon, who failed to order transfusions of blood and plasma for a patient who had lost a large amount of blood. Only 2 incisional hernias, both small, were observed, and there was 1 instance of recurrent incisional hernia in a patient in whom repair was inadequate. The

incidence of postoperative complications was 2.63 and 1.4 per cent respectively, for 1,504 operations from 1906 to 1912, in which period the patients were allowed out of bed at the end of the second week. The corresponding incidence for the 2,053 operations during the next six years, when the patients rose between the second and fifth postoperative days, was respectively 1.75 and 0.6 per cent. Von Eschke (cited by Ochsmner and DeBakey) presented similar figures: Among 300 cases in which late rising was practiced the incidence of thrombosis and fatal embolism was respectively 1 per cent, as compared with 0.5 and 0 per cent respectively among 387 cases in which early rising was practiced.

Fear that the wound will fail to heal properly is the chief objection advanced to early ambulation, and it is easy to understand why it exists, since the dependence of the healing of a wound on immobilization has been taught since ancient times. To this objection there are two possible replies: 1. Improvement in surgical technique and, in particular, improvement in suture material make a comparison with reports of even a decade ago misleading. 2. There is a complete absence or an extremely small percentage of disruptions of the wound in the reported series of operations after which early ambulation was practiced.

Proof exists, furthermore, that early rising hastens the healing of a wound, whereas late rising (restricted movement) hinders it. In 1936 Kinnarovsky (cited by Newburger) reported an experimental study which showed a delay in fibroplasia in dogs in which exercise was restricted after abdominal incision, and Shans, Pozharsky and Abrikosov agreed with this conclusion. Newburger,<sup>12</sup> in 1943, demonstrated that exercise rather than immobilization expedited the healing of wounds in experimental animals submitted to incision of the abdominal wall. There was a notable acceleration of the acquisition of tensile strength in the unrestricted animals, as the result of a shortening in the lag period, or, conversely, a more rapid initiation of the period of fibroplasia, as compared with the processes studied in control animals. Clinical proof as to the effect of unrestricted movement on the healing of wounds is furnished in the various reports cited throughout this communication.

The advantages of early rising observed in our own series corroborate those listed by Boldt in his report. The improvement in the patient's morale is a psychologic advantage which must

12. Newburger, B.: Early Postoperative Walking: I. The Influence of Exercise on Wound Healing in Rats, *Surgery* 13:692-695 (May) 1943.

single fatality in the series was due to cerebral thrombosis. Good results depend on the strict observance of contraindications as well as of indications. The advantages of the plan include the lowered incidence of postoperative complications, particularly pulmonary and vascular complications; the lower incidence of nausea, vomiting and abdominal distention; the earlier return of normal function of the bladder and the bowel; the maintenance of normal muscle tone; the psychologic effect on the patient's morale and mental status; the acceleration of convalescence and the earlier return of working ability; the economic savings to the patient and the hospital. For the reasons stated, and because of its apparent absolute safety, the plan of early postoperative ambulation seems to represent a sound surgical advance, and its more general employment in properly selected cases is recommended.

# CYSTIC TUMOR OF THE ILIOPECTINEAL BURSA

REPORT OF TWO CASES

VIRGIL R. STEPHENS, M.D.

CHICAGO

Cystic enlargement of the iliopectineal bursa is comparatively uncommon. Gatch and Green<sup>1</sup> were able to collect only 32 cases up to 1925 in an exhaustive study of the literature. They added 1 of their own in which a woman aged 60, had a swelling in the groin about the size of a hen's egg. There were no symptoms. Menninger<sup>2</sup> in 1932 reported an iliopectineal bursa the size of a goose egg in a man 36 years of age, with no history of trauma. The mass was excised and found to be communicating with the hip joint by a small opening. In 1933 O'Connor<sup>3</sup> reported 33 cases of iliopectineal bursitis, in 7 of which operation was done. In at least 10 of the cases there was palpable but not necessarily visible enlargement. A good description of the symptoms and signs is given, and the methods of treatment are well outlined. FINDER<sup>4</sup> in 1938 described a case in which a large cystic cavity contained 500 cc. of serous fluid. It was treated by incision and drainage. The nature of the cyst was established by the finding of a small opening into the cavity of the hip joint. Muscle fibers were planted within the wide open cavity to prevent recurrence. Two cases of cystic enlargement of the iliopectineal bursa which I have observed recently are presented herein.

CASE 1.—B. S., a farmer aged 73, presented himself at the MacNeal Memorial Hospital July 21, 1943, with a tender mass in the left groin, which interfered with his gait and prevented full extension of the thigh. He complained of weakness in the area of the quadriceps muscle (anterior part of the thigh) and considerable

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1. Gatch, W. D., and Green, W. T.: Cysts of the Ilio-Psoas Bursa, *Ann. Surg.* 82:277, 1925.

2. Menninger, W.: Ueber Entzündung der Bursa iliopectinea, *Deutsche Ztschr. f. Chir.* 237:775, 1932.

3. O'Connor, D. S.: Early Recognition of Iliopectineal Bursitis, *Surg., Gynec. & Obst.* 57:674, 1933.

4. FINDER, J. G.: Iliopectineal Bursitis, *Arch. Surg.* 36:519 (March) 1938.

CASE 2.—M. D., a retired motorman aged 84, appeared in my office Dec. 10, 1943, complaining of severe and constant pain in the region of the right hip joint of three months' duration, with the pain radiating down to the knee; he walked with a pronounced limp. He first noted a lump in the right inguinal region one and one-half years before coming to my office. On examination a hard tumor mass, the size of a hen's egg, was seen just distal to Poupart's ligament, directly under the anterior femoral nerve. On palpation the mass appeared to be solid, and the femoral arterial pulsation over the top of the tumor suggested a possible aneurysm. However, the artery could be observed above the tumor and slightly to the medial side of its center. No fluctuation could be felt, and no fluid could be aspirated. In a second trial a week later, after attempting aspiration in four or five different places, I was finally able to secure 2 cc. of clear, slightly viscid fluid.

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This report is not especially concerned with the treatment of bursitis of the type represented by a small cystic tumor not associated with a joint, but in the main such treatment should be along conservative lines, as recommended by O'Connor. Cystic enlargements of various bursas may require operative treatment when they become chronically infected and do not respond to simple treatment after fair trial or when

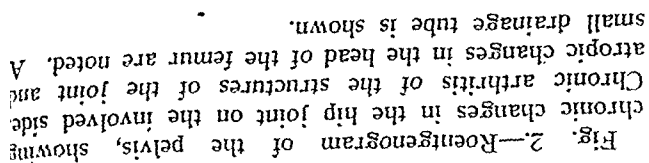
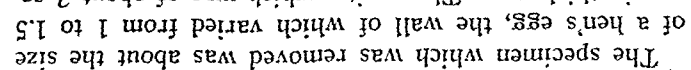


Fig. 2.—Roentgenogram of the pelvis, showing chronic changes in the hip joint on the involved side. Chronic arthritis of the structures of the joint and atrophic changes in the head of the femur are noted. A small drainage tube is shown.

they become mechanically or cosmetically a nuisance. The simplest method of intervention is aspiration followed by administration of a sclerosing agent in properly selected cases. When acute suppurative occurs, incision with or without a pack may be in order.

Fig. 1.—The drawings indicate the gross appearance of the cystic cavity to the hip joint, as encountered in the 2 cases herein reported. The cyst communicated with the joint in case 2 but not case 1.



cm. in thickness. The cavity, which was of about 2 cc. capacity, was lined with apparently ordinary synovial membrane, and there were no calcified masses demonstrable in the wall of the bursa itself, which consisted mostly of a dirty, dull, wrinkled, tough fibrous mass. Two weeks after operation tenderness and swelling appeared in the line of the incision, and a few days later a thin "mucoid" pus was obtained by thrusting a hemostat into the lower portion of the wound. A no. 18 catheter was inserted between the muscles in the track of the old incision to the cavity where fluid was collecting. Drainage lasted about two weeks, during which time the hip joint and the wound remained sensitive; the patient had no fever.

The 2 cases of visible enlargement of the iliopectineal bursa herein described present uncommon lesions, according to several recognized

Healing by first intention after removal of the pack usually occurs.

#### SUMMARY

Cystic tumor of the iliopectineal bursa occurred in 2 elderly men whose occupations involved strenuous use of the lower extremities. In 1 case, in which the bursa was not connected with the cavity of the hip joint, there were no corresponding changes in the structures of the hip joint. In the other case, however, in which the bursa had a wide-open communication with the cavity of the hip joint, there were distinct arthritic and atrophic changes in the structures of the joint.

The sterile gauze pack saturated with sylvasol.<sup>2</sup> The pack may be left one to four days, that is, until the sac is thought to be destroyed. Drainage of the excess sclerotic agent into the dressings prevents an overdosage. If desired the pack may be recharged with the sclerotic agent, with or without a needle on the syringe; the need of a recharge depends on the resistance and the thickness of the wall of the cyst. Pink drainage suggests that the wall has probably been destroyed.

5. Sylvasol is a 5 per cent solution of the sodium salts of certain of the fatty acids of the oil extracted from a seed of the psyllium group, with 2 per cent benzyl alcohol added for its anesthetic effect.

## CLINICAL OBSERVATIONS ON TISSUE TEMPERATURES

FRANK K. SAFFORD JR., M.D., AND MAX B. NATHANSON, M.D.

cyanosis). The common factor to all these terms is the implied effect of relative cold.

TEMPERATURES FOR ANESTHESIA FOR

In order to determine optimum temperature for satisfactory anesthesia for an amputated limb, the duration of refrigeration necessary

obtain these temperatures, systematic readings were made for more than 30 patients during refrigeration preliminary to the amputation. For the most part the amputations were done through the lower part of the thigh, after refrigeration produced by means of the more commonly used cracked ice pack with a tourniquet. The technique of application has been variously described.<sup>3</sup> Because of its greater convenience and ease of application, however, mechanical refrigeration was used whenever possible. Tables I and

was used whenever possible. Tables I and II show the procedure followed in measuring temperatures during each of these two techniques. They also show the degree and duration of cooling necessary for what was termed "satisfactory" anesthesia. The requirements for this designation were: There should be not more than slight pain or bleeding or lowering of blood pressure during the operation, and the patient should feel able to eat a regular meal in comfort two to four hours after the operation. If slight pain was felt when the sciatic nerve was cut but there was no bleeding, the anesthesia was designated "good," as shown in table 3. In most of the cases of this study, because the degree of refrigeration was low enough and the tourniquet adequately applied, no pain was felt and no blood lost. In these cases the anes-

3. (a) Allen, F. M., and Crossman, L. W.: *Arch. Phys. Therapy* **23**: 711 (Dec.) 1942. (b) Allen, F. M.: *Anesthesiology* **4**: 12 (Jan.) 1943; (c) *Anesth. & Analg.* **22**: 264 (Sept.-Oct.) 1943. (d) Crossman, L. W.; Ruggiero, W. F.; Hurley, V., and Allen, F. M.: *Reduced Temperatures in Surgery: Amputations for Peripheral Vascular Disease, Arch. Surg.* **44**: 139 (Jan.) 1942. (e) Mock, H. E., and Mock, H. E., Jr.: *Regeneration Anesthesia in Amputations, J. A. M. A.* **123**: 13 (Sept.) 1943. (f) McElvenny, R. T.: *Am. J. Surg.* **58**: 110 (Oct.) 1942. (g) Gordon, J. D.: *ibid.* **58**: 453 (Dec.) 1942. (h) Kennedy, J. A.: *U. S. Nav. M. Bull.* **41**: 226 (Jan.) 1943. (i) Newman, M. K.: *Arch. Phys. Therapy* **24**: 389 (July) 1943.

In the course of work on refrigeration anaesthesia at New York City Hospital it seemed advisable to make studies on temperatures of tissue in order to determine: (1) the optimum temperatures necessary for satisfactory anaesthesia; (2) the duration of refrigeration necessary to obtain these temperatures; (3) the minimum temperatures above which tissue must remain in order to avoid damage.

As these studies were in progress other observations became of interest, namely, the effect of the tourniquet; the optimum temperatures for prolonged refrigeration in the treatment of burns, frostbite and infections, and, finally, the temperatures that were effective and safe for reducing pain in conditions such as arthritis and

neuritis.

The methods of refrigeration studied included the use of cracked ice, ice water, ice bags, electric fan plus water spray, ethyl chloride spray and mechanical refrigeration. The latter was obtained by means of a refrigerating unit<sup>1</sup> which is a fluid (35 per cent alcohol) to the desired temperature—as low as 20 F.—and pumps this through suitably shaped applicators of coiled al or rubber tubing or through aluminum-ed metal tubing of a cold air chamber. A eds and Northrop potentiometer<sup>2</sup> and a thermocouple with an iron-constantan needle were ed to measure temperatures. These were recorded in Fahrenheit degrees and should be accepted as approximate. The temperatures of the skin represent for the most part the mean of two or three readings.

No attempt has been made to distinguish between the commonly used terms hypothermia, cryotherapy, refrigeration, reduced temperature, and cooling or between the terms describing the clinical picture of frostbite (immersion foot, trench foot, shelter foot, chilblain and erythro-

1. Made by the Therm-O-Rite Products Company, Buffalo.



finger and the finger held in a glass of ice water, fifteen minutes is ample time to obtain "excellent" anesthesia. (This is demonstrated in table 5.) By means of prolonged refrigeration without a tourniquet, as seen in table 3. Also anesthesia may be produced by refrigerating only the area in the neighborhood of the operating field, as demonstrated in table 4. The latter two procedures, however, were tried only once, on patients with advanced vascular pathologic conditions, and therefore are not recommended.

TEMPERATURES THAT MAY DAMAGE TISSUE

In one of the earlier papers on refrigeration Allen<sup>4</sup> stated that "refrigeration for more than 40 to 50 F.

Temperature of skin in region of operation

amputations on the thigh:

Such an example was called "excellent." Many factors affect both the degree and the ration of refrigeration; among them are the anesthetic and the vascular pathologic condition of the extremity, the degree of contact between cutaneous and refrigerating surfaces and the fitness of the tourniquet. It is preferable, therefore, to allow a margin of safety in the amputation both of the duration and of the degree of cooling. This margin is allowed for in the following temperatures and duration of refrigeration recommended for satisfactory anesthesia

TABLE 1.—Refrigeration of the Whole Leg by Means of the Cracked Ice Pack

Refrigeration for three hours (two hours with a tourniquet) preliminary to a guilotine amputation through the upper part of the thigh.

12:21/43, 8:30 A. M.	Before refrigeration; leg was exposed to room temperature for 5 minutes; cracked ice was then applied	74	76	78	97	75
Room temperature	74	76	78	97	75	
Temperature under bed covers	50	59	97.6	97	40.5	
Temperature of large toe	91.5	82	62	57.5	40.5	
Of dorsum	92.5	66.5	44	36	47.5	
Of calf	92	70	39	37.5	40.5	
Of knee	92	64.5	37	36.5	40.5	
Of upper part of thigh	87.5	63	38	35.5	40.5	
In region of calf	94.5	74	44	40.5	47	
In subcutis 1½ in. (.6 cm.) deep	99	81	62	47	40.5	
In region of upper part of thigh	96.5	71	46	40.5	40.5	
In subcutis ½ in. (.6 cm.) deep	99.5	86	79	40.5	40.5	
In muscle 1½ in. deep	99.5	86	79	40.5	40.5	

Comment.—M. H., aged 65, was treated for osteomyelitis of the left femur. The tourniquet in this case was applied fifteen minutes after the refrigeration was begun, in order that the leg would be somewhat anesthetized against the pain of the amputation. It would have been preferable to wait perhaps twice as long. Also, because of the large diameter of the patient's extremities and the necessity of placing the tourniquet high (2 inches [5 cm.] below the groin), another hour of refrigeration might have made the anesthesia "excellent." (The routine technique, more frequently followed, was to refrigerate the area of the skin over the tourniquet was to be applied by binding four uncovered ice bags to this region for thirty minutes to two hours before applying the cracked ice pack to the whole leg.) The anesthesia was designated "satisfactory."

\* All temperatures are expressed in Fahrenheit degrees

Temperature of deep tissue (1½ inches [3.8 cm.] below the skin) 45 to 65 F.

Minimum duration of refrigeration three hours.

Minimum duration of refrigeration two hours.

For amputations on thighs of large diameter and normal circulation the duration of refrigeration might preferably be longer; with reverse conditions, shorter, as shown in tables 1 and 4

For amputations of the lower part of the leg, with a tourniquet placed below the knee, or for amputations of toes, with the tourniquet above the ankle, the duration of refrigeration would be shorter. For incisions for a paronychia, with rubber band as a tourniquet at the base of the

a few hours is believed to be contra-indicated in any limb which is to be saved." He was referring to deep refrigeration by means of cracked ice and a tourniquet. In the meantime, however, the literature has frequently mentioned the possibility of prolonged deep refrigeration without perhaps enough caution regarding possible damage to tissue. McElvenny<sup>37</sup> spoke of how well preserved the tissue of a leg appeared after twenty-eight days in ice. However, the leg was removed immediately thereafter, he reported. Greene<sup>2</sup> (two years after Allen's reported. Allen, F. M.: Surg., Gynec. & Obst. 68:1047 (June) 1939.

5. Greene, R.: Lancet 2:689 (Dec. 6) 1941.

Refrigeration three and one half hours (two and one fourth hours with a tourniquet) preliminary to an amputation through the lower part of the thigh.

12/10/13, 10 A. M.	Before refrigeration; After ½ hours refrigeration; room temperature 5 minutes; Therm-O- rite applicator was then applied
11 A. M.	After ½ hours refrigeration; tourniquet was then applied
1 P. M.	After 2½ hours' refrigeration
1:30 P. M.	After 3 hours' refig- eration; operation followed at 1:45 p. m.

Comment.—R. H., aged 75, was treated for arteriosclerotic gangrene of the left large toe and cellulitis. The tourniquet in this case was not adequately applied (possibly because of the poor quality of rubber), with the result that some bleeding occurred. There was also slight pain when the sciatic nerve was cut. The anesthesia was therefore designated "satisfactory." For "excellent" anesthesia the temperature of 67 F. in the deep muscular tissue of the thigh was not low enough.

TABLE 3.—*Prolonged Refrigeration of the Leg by Means of the Therm-O-Rite Applicator*

[illegible]

Comment.—H. R., aged 48, suffered from gangrene of the left foot. The intention in this case was to determine how effective refrigeration anesthesia without a tourniquet might be. Moderate refrigeration (45 F.) was applied over night, followed by more intense refrigeration (36 F.) for two and three fourths hours before the operation. The temperature of 46.5 F. in deep muscular tissue of the thigh, one half hour before operation, promised the good result that was obtained. Because of the patient's poor condition and the desirability of avoiding loss of blood, a tourniquet was applied at the last minute, while the anesthesia was being prepared for operation. The anesthesia was designated "good."

between 0 and 5 C (32 and 41 F.).<sup>6</sup> Since earlier in the same paper he had emphasized the fact that "necrosis is a vital process," it is surprising that Greene should have based a method of clinical treatment on in vitro observations.

good will not part with its oxygen if the skin below 10 C. (50 F.)" they thought it "illogical to reduce the temperature of the already damaged tissues below 10 C."

In the course of the present study to determine at temperatures damage tissue, 3 cases of frostbite were observed. In all 3 cases frostbite

interruption of refrigeration. It is speculatively believed that all 3 might have been avoided by gradual instead of sudden warming.

TABLE 4.—Refrigeration of the Leg in the Region Between the Mid thigh and the Mid tibia by Means of the Cracked Ice Pack

Refrigeration for two and one half hours (two hours with a tourniquet) preliminary to an amputation through the lower  
: of the thigh. The lower leg and the foot were not refrigerated.

Time	Treatment	Temperature	Observations
4/29/43, 12:45 P. M.	Cracked ice applied from mid thigh to mid tibia	78	After 2 hours' refrigeration (1½ hours with tourniquet)
1:15	Tourniquet applied 8 in. above knee	78	Amputation through the lower part of thigh; result: "excellent", no bleeding
2:45		78	
3:15		78	

1. The temperature of the deep musculature of the legs was measured after two hours.

TABLE 5.—Refrigeration of the Fingers of the Left Hand in a Glass of Ice Water

The fourth finger was reirrigated with a tourniquet. The third finger was reirrigated without a tourniquet. The finger was not reirrigated, but a tourniquet was applied. Rubber bands were used as tourniquets.

Time		Temperature		Remarks	
10/22/43, 3 P. M.	Before refrigeration	92.5	94.5	Of tip of third finger (refrigeration without tourniquet) .....	94
		93.5	96	Of tip of fourth finger (refrigeration with tourniquet) .....	95
		..	44.5	Deep tissue temperature in subcutis ½ in. (0.6 cm.) deep. Of tip of fifth finger (tourniquet without refrigeration) .....	
3:15 P. M.	After 15 minutes' refrigeration	86.5	71	Of tip of third finger (refrigeration without tourniquet removed) .....	96
3:30 P. M.	After 30 minutes' refrigeration	81.5	60	Of tip of third finger (refrigeration without tourniquet removed) .....	97
8:40	10 minutes later			Of tip of third finger (refrigeration without tourniquet removed) .....	

Comment—At N. level 3, reported complete anesthesia in the fourth finger. (The insertion of the thermocouple needle is not felt when the subcutaneous temperature is 40.5 F. In this finger, it was slightly, if any, anesthetic in the other two fingers. Of interest was the lowering of the temperature of the skin by 2.5 F. in the fifth finger as a result of the cooling effect of the water. Also, water temperature, because this finger was not insulated from the cooling effect of the air and the tap water. Also, of interest, was the following: This patient reported marked paresthesia in his fifth finger for six weeks following the application of a tourniquet for fifteen minutes. Slight paresthesia was felt in the fourth finger for one week following the application of a tourniquet for fifteen minutes plus refrigeration. No paresthesia was felt in the fourth finger after the fifteen minute refrigeration without a tourniquet.)

9. This patient was treated under the direction of Dr. Isidore Kross. At the critical time, it was his decision to try refrigeration therapy, in order to avoid an amputation which under the circumstances was felt might have cost the patient her life.

allowed prolonged artificial refrigeration (more than twenty-four hours). The lowest temperature of the skin recorded where blisters due to frostbite occurred was 39 F. (table 7). They never appeared during refrigeration but were first noticed twelve to forty-eight hours after the rapid warming of the part to the temperature of the bed (88 to 94 F.), following the sudden

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in the course of the present study to determine at temperatures damage tissue, 3 cases of stibite were observed. In all 3 cases frostbite

Comment.—In this case the points of interest to the present study were: (1) the question of burn as the cause of the initial lesion; (2) the first dramatic effect of refrigeration on the severe effects.

TABLE 6.—Refrigeration of the Trough by Means of the Therm-O-Rite Applicator

Refrigeration in order to obtain anesthesia of the muscles of the thigh while traction was applied to the contracted left leg.

	Room temperature	Oral temperature	Temperature of Thermo-O-Rite fluid	Cutaneous temperature	Of dorsum	Of call.	Of mid thigh	Deep tissue temperature of mid thigh In subcutis $\frac{1}{8}$ in. (0.6 cm.) deep. In muscle $1\frac{1}{2}$ in. (4 cm.) deep.	Rite of contracture of knee.
Before refrigeration; Therm-O-Rite applied after was thereafter applied	75	98.6	40	90.5	90.5	89	92.5	97	90 degrees
11:30 A. M.	75	98.6	40	90.5	90.5	89	92.5	97	90 degrees
After 24 hours' refrigeration; temperature of fluid was thereafter lowered to 32 F.	73	98	40 32	82.25	66	62	77	88.75	160 degrees
11:30 A. M.	73	98	40 32	82.25	66	62	77	88.75	160 degrees
3½ hours later; refrigeration was thereafter discontinued	76	97.6	32	76.5	57.5	45	45	68	160 degrees
1/3/43, 3 P. M.	76	97.6	32	76.5	57.5	45	45	68	160 degrees
2 days later; leg had been exposed to temperature of bed; blisters due to frostbite appeared on thigh	78.5	99						98	100.5
1/7/43, 3 P. M.	78.5	99						98	100.5

inment.—M. M., aged 49, was treated for contracture of both legs and possible multiple sclerosis. Anesthesia was not satisfactory. Further comments on this case appear in the text.

. this time, because of the continuous drainage and use of the sweating of the cold rubber applicator, as feared that the skin would become macerated. cold air chamber, with the temperature of the air at 50 F., was therefore substituted. The cooling of this chamber, however, was inadequate, either because the chamber was not kept in position or because the patient was not cooperative. On the following day the cutaneous temperatures had climbed to 82 to 92 F., the oral temperature rose and the odor returned. The Therm-O-Rite applicator was therefore reapplied, with the temperature of the fluid set at 50 F.

On the following day frostbite blisters on the knee and toes were first noticed. It was observed that these

infection of the limb; (3) the healthy pink flush of the skin following the first few hours of refrigeration; (4) the appearance of frostbite blisters after a brief rapid warming of the limb to the temperature of the bed, and (5) the final slow (but also dramatic in extent) epithelialization and healing during over two months of moderate refrigeration.

In regard to the question of burn, reference is again made to an earlier paper by Allen.<sup>11</sup> Speaking of the effect of a temperature of 102 F. on the ligated limbs of rats, he remarked:

recalled.  
From this time on, for a total of eighty-nine days of refrigeration, the cutaneous temperatures were main-

11. Allen, E. M.: Am. J. Surg. 45:459 (Sept.) 1939.

CASE 2.—The tissue temperatures recorded for the second patient in whom frostbite blisters developed during refrigeration are shown in table 6.

The intention in this case had been to obtain anæsthesia of the contracted muscles of the thigh while the leg was under traction. The angle of the contracture of the knee was increased from 90 to 160 degrees, but manipulative stretching beyond this point, despite cooling, was painful. The anæsthesia, therefore, was not successful, possibly because the Thermo-O-Rite applicator did not include the knee and hip.

Forty-eight hours after the refrigeration was discontinued two small frostbite blisters appeared on the lateral part of the thigh, where the lowest recorded cutaneous temperature had been 45 F. Here again the blisters probably resulted from the combination of slight pressure with moderate cold and rapid warming. They were indistinguishable from blisters caused by burns, especially those which follow the use of hot water bottles on the bloodless tissue of patients in shock.

At times follows operation on the brain, injury to the Thermo-O-Rite applicator was used for reducing high temperature, such as frequently described. Incidentally, when operation on the severe infection of the limb, has a marked effect of the first few hours of refrigeration. The second point of interest, namely, the inability from a burn.

However, which caused a lesion clinically indistinguishable from a burn.

circulation, to the relatively mild heat of the of her leg, partially asphyxiated by lack of also in this case it was believed that the patient's initial lesion was the result of exposing which felt comfortable to him and his companions. The writer witnessed one case of an arteriosclerotic in whose feet were severely blistered in a Turkish

TABLE 7.—*Prolonged Refrigeration of the Leg by Means of the Therm-O-Rite Applicator and Salted Ice*

[illegible]

Comment.-J. N., aged 65, had osteomyelitis of the left os calcis and diabetic gangrene. Further comments on this case near in the text.

There was an interesting sequel to this treatment. A day or so later it was decided to use the Them-O-Rite applicator as a heating pad on the patient's other contracted leg in the effort, through heat, to relax the muscles of the thigh, while the leg was kept overnight in traction. The temperature of the fluid was set at 102 F. The applicator felt comfortably warm, not hot, to the patient; yet the following day two small burn blisters appeared on this leg. By this time there was no question of the exact similarity between the frost-bite blisters, appearing where the cutaneous temperature was over 40 F., and the burn blisters, where the temperature could not have been over 102 F. These blisters healed in a few days with equal rapidity. Incidentally, the application of heat had also failed to correct the contracture.

CASE 3.—Table 7 describes the third case of frostbite blisters from the point of view of the tissue temperatures taken before, during and after the appearance of these lesions.

12. Fay, T.: Personal communication to the authors.

tained during refrigeration without a tourniquet (compare with table 3). The effectiveness of the anesthesia was well demonstrated when biopsy specimens were taken without causing pain. We recalled Moeck's<sup>14</sup> use of refrigeration for surface anesthesia for pinch grafts and also in the North Atlantic suffering from immersion foot. Webster<sup>15</sup> described their feet as "anesthetic to pain, touch and temperature." Finally, the overnight oozing of blood during removal of the biopsy specimens made for refrigeration from the incisions seemed of interest. This prolonged bleeding as an effect of cold has been mentioned elsewhere (Allen,<sup>3b</sup> Lange<sup>16</sup>) and deserves further explanation.

Meanwhile the study of "Temperatures That May Damage Tissue" warranted the following conclusion: Cutaneous temperatures maintained below 50 F. for more than twelve hours may be damaging if contributing factors are present. These factors are: Pathologically or anatomically reduced circulation in the tissue exposed; combination of pressure with cold, and subsequent rapid warming of refrigerated tissue. It will be explained later how the last-mentioned factor is believed important and for the most part overlooked. Pressure apparently has an effect, whether it is applied to the same area as the cold or proximal to that area, as frequently happens in cases of shelter foot, trench foot and immersion foot.

Although this conclusion had been anticipated it seemed important, because of lack of sufficient caution in the literature, to demonstrate it and emphasize it.

#### SUMMARY AND COMMENT

The first three aims of this study of tissue temperatures had by this time been completed: the determination of optimum temperatures for refrigeration anesthesia, the determination of the duration of refrigeration necessary to obtain these temperatures and the determination of reduced temperatures which, along with other factors, may damage tissue. The other aims, namely, the study of the effect of the tourniquet and of optimum temperatures for refrigeration used therapeutically, were but partially completed. Furthermore, a number of problems that seemed to need further elucidation had turned up, such as the prolonged bleeding as

This patient had been in acute pain from the gangrenous infection of his foot. It was finally decided to amputate, but until the operation could be arranged much as the patient was completely relieved of his pain within two hours, he was grateful for the prolonged refrigeration that followed and willing to allow the four biopsies.<sup>17</sup> The specimens for the first two biopsies were taken during refrigeration from areas of the calf where the cutaneous temperatures were 45 F. and 39 F. respectively. The specimen for the third biopsy included a frostbite blister, which in this case also had appeared after rapid warming, following prolonged refrigeration. The tissue for the fourth biopsy, taken at the time of amputation, included a blistered area that had been exposed to salted ice for one hour, during the prolonged refrigeration, and then rapidly warmed. The salted ice lowered the temperature of the skin to 34 F.

**Biopsies 1 and 2** (made after refrigeration for five and one-half and eleven hours respectively).—(Grossly the skin appeared bright red. Microscopically the appearance was normal.

**Biopsy 3.**—(Gross Observations: Tissue from the left calf taken twenty-eight hours after the twenty-seven hour refrigeration was discontinued included a frostbite blister (second degree). The skin appeared as in a second degree burn but was normal outside of the blistered area.

**Microscopic Observations:** The surface epithelium was desquamated, with the papillary layer of the derma left exposed. The vessels were engorged and frequently contained a high polymorphonuclear content. The perivascular regions were edematous and had infiltrates of polymorphonuclear leukocytes and lymphocytes. The hair shafts and particularly the sebaceous glands were necrotic and infiltrated by degenerating polymorphonuclear cells. The surrounding area had the same type of infiltrate found in the perivascular regions. Thrombi absent.

**Biopsy 4** (made immediately after amputation).—**Observations:** In a specimen (taken after the application of salted ice the skin appeared like a second degree burn; the blister had opened and peeled with the underlying tissue dark red and oozing. **Microscopic Observations:** The surface epithelium was denuded, with only an occasional remnant peg left. The superficial derma was degenerating and had a diffuse, slight scattering of necrotic inflammatory cells. In the deeper layers the perivascular areas had a slight polymorphonuclear and lymphocytic infiltrate. Thrombi were absent.

**Comment.**—What seemed significant in the latter two reports was the final statement in each: "Thrombi were absent." In other respects the reports might apply equally well as descriptions of second and third degree burns. This similarity between frostbite and burn, not infrequently observed by others, seemed worthy of more study.

Of further interest in this third case of frostbite were the low anesthetic temperatures ob-

13. The biopsy reports were obtained through the courtesy and cooperation of Dr. J. R. Lisa, pathologist at New York City Hospital.

14. Moeck, H.: Bull. Am. Coll. Surgeons 28:56, 1943.
15. Webster, D. R.; Woolhouse, R. M., and Johnson, J. L.: J. Bone & Joint Surg. 24:785 (Oct.) 1942.
16. Lange, K.: Bull. New York M. Coll., Flower & Fifth Ave. Hosps. 5:154 (Dec.) 1942.

work,<sup>17</sup> as well as of observations on the treatment of infection and frostbite described in this study (case 1 and table 9). The optimum temperature of 70 F. is higher than that suggested by Greene,<sup>5</sup> lower than that recommended and used by a number of others<sup>18</sup> and roughly in agreement with the point of view of Rossiter,<sup>19</sup> who recently advised for the treatment of burn "ensuring that the skin of the burned area is kept at a temperature of 70 to 80 F."

It is further suggested that the usual custom of treating burn, frostbite and infection at room temperature, aside from being easiest, probably has no other advantage. Room temperature, obtained by means of an electric fan and water spray (recommended by Webster), as demonstrated in table 8, can be effective. As a rule, cold air, because it avoids the effects of pressure, is preferable to covered ice bags or cold appli-

TABLE 8.—*Refrigeration of the Lower Part of the Left Leg and Foot by Means of an Electric Fan Plus Water Spray*

12/10/43, 9:15 A. M.		9:45		10:00		10:15	
Lower part of leg exposed to room temperature for 5 minutes		After 30 minutes' exposure to electric fan		After 45 minutes' exposure to electric fan; water then sprayed from atomizer		15 minutes after water spray	
Of foot.....	84	77	78	78	74	76.5	74
Of dorsum.....	89.5	79.5	79.5	79.5	76.5	76.5	76.5
Of calf.....	90	81	78	78	75.5	75.5	75.5
Of knee.....	91.5	82	78	78	75.5	75.5	75.5
Of thigh.....	93.25	82	81	81	76.25	76.25	76.25
Of tissue temperature of calf in subcutis ½ in. (0.6 cm.) deep.....	92.75	..	..	..	78.5	78.5	91
In muscle 1½ in. (4 cm.) deep.....	97.5	..	..	..	..	..	..

Comment.—R. H., aged 73, suffered from arteriosclerotic gangrene of the left toe. Because of the advanced pathologic condition of this extremity to begin with, the low temperatures quickly obtained were not thought to be a criterion of what is generally possible. Nevertheless, the effectiveness of the electric fan plus water spray, recommended by Webster and White as a method for moderate cooling, was verified.

more quickly and easily lowered through the addition of the effect of the tourniquet, but because of this rapid lowering of temperature, an intermediate attempt on the part of the tissue toward a compensatory adjustment to cold is avoided and as a result perhaps less damage to surface tissue sustained, frostbite on the skin being less likely to appear. This does not imply that amage to nerves is avoided. Paresthesia, even artial paralysis, especially when cold is inadequate, may follow, as demonstrated in tables 5 and 10. Meanwhile the advantage of the tourniquet for inducing anesthesia for an amputation as become obvious.

In regard to the question of optimum temperatures for prolonged therapeutic cooling, it suggested that an average cutaneous temperature of 70 F. is probably optimum and that in general temperatures below 80 F. and above 60 F. or prolonged treatment are more favorable than temperatures beyond these extremes. In support of this suggestion is the evidence of previous

catars of other types. The duration of treatment may vary, according to the symptomatic picture, from as short a period as minutes or hours, for different degrees of shock, to as long as months, as in the treatment described here. Finally, it is advised that by frequent measuring of tissue temperatures therapeutic cooling can be correctly guided and justified.

In regard to the bright red color of the skin following brief exposure to moderate cold, this, as has already been said, is probably due to the

17. Allen, F. M.; Crossman, L. W., and Safford, F. K., Jr.: New York State J. Med. 43:951 (May 15) 1943.  
18. (a) Starr, K., Jr.: Am. J. M. Sc. 187:498 (April) 1934. (b) Freeman, N. E.: Influence of Temperature on Development of Gangrene in Peripheral Vascular Disease, Arch. Surg. 40:326 (Feb.) 1940. (c) Ungley, C. C., and Blackwood, W.: Lancet 2:447 (Oct. 17) 1942. (d) White, J. C.: New England J. Med. 228:213 (Feb. 18) 1943. Davis and others,<sup>7</sup> Webster and others,<sup>19</sup>  
19. Rossiter, R. J.: Bull. War Med. 4:181 (Dec.) 1943.

higher content of oxygen in the blood of the cooled area.<sup>20</sup> However, whether the bright color is present because oxygen does not chemically dissociate from cooled blood<sup>26</sup> or also because capillary permeability is reduced<sup>16</sup> or because the vasoconstriction has emptied the capillaries and short-circuited the blood through arterio-venous anastomoses<sup>21</sup> without irritating superficial tissue remains to be further investigated. In regard to prolonged bleeding as an effect of cold, the theory of reduced enzymatic activity of the blood, including its coagulating process, offers probably the best explanation. This effect of cold in reducing fermentative activities, as well as tissue metabolism, apparently follows the formula<sup>22</sup> of van't Hoff, which implies that the speed of chemical activity is increased or decreased two or three times for every 10 C. (18 F.) rise or lowering of temperature. The importance of this law in relation to reduced tissue temperature was pointed out by Askamazy.<sup>23</sup> In regard to the similarity of burn and frostbite, it should be emphasized again that because of the limited nature of past investigations answers to this question remain particularly speculative. For example, of twenty histologic studies of lesions due to reduced temperature found in the literature of the past twenty odd years, with one exception,<sup>24</sup> none was made on tissue subjected to biopsy or autopsy during exposure to cold. Most of the examinations performed at least hours after the tissue been relatively warmed. When one realizes this warming usually involves exposing tissue which is below 40 F. to temperatures above F. (a difference of at least 30 degrees) and keeping van't Hoff's formula in mind, one remembers how it feels to dip the hand with normal cutaneous temperature, of 90 F., into water at a temperature of 120 F. (30 degrees difference), it is not too fantastic to assume that most of the aforementioned twenty histologic studies were made on tissues, relatively speaking, burned by the contrast of temperature. The reason that frostbite has been so frequently compared to burn becomes more clear.

In regard to the absence of thrombosis in certain frostbite lesions, if one speculates further,

20. Goldschmidt, S., and Light, A. B.: *Am. J. Physiol.* 73:146 (June) 1925.

21. (a) Lewis, T.: *Brit. M. J.* 2:795 (Dec. 6) 1941. (b) Theis, F. V.: *Arch. Phys. Therapy* 21:663 (Nov.) 1940.

22. Getman, F. H.: *Outline of Theoretical Chemistry*, New York, John Wiley & Sons, 1928, p. 438.

23. Askamazy, M., in Aschoff, L.: *Pathologische Anatomie*, Jena, Gustav Fischer, 1923, vol. 1, p. 68.

24. Brooks, B., and Duncan, G. W.: *Ann. Surg.* 114: 1069 (Dec.) 1941.

1943.

28. Ebin, J.: *Surg., Gynec. & Obst.* 76:43 (Jan.) 1938.

27. Jahnel, F.: *Klin. Wchnschr.* 17:1273 (Sept. 10) 1941.

26. Kukin, N. N.: *Arch. Sc. Biol., Moscow* 62:21 1937.

25. Landis, E. M.: *Am. J. M. Sc.* 193:297 (March) 1937.

In most burns capillary endothelial cells are damaged primarily less by anoxia than by the direct coagulating effect of heat, which causes formation of thrombi, typical of burned tissue. In most lesions due to cold, on the other hand, endothelial cells are damaged probably less by direct effects of temperature than by anoxia. This anoxia, depending on the contrast of the external temperature (compare the usual rapid warming following exposure to cold), may be multiplied threefold or fourfold (van't Hoff), resulting in a fourfold increase of damaging metabolites. If the cold is not too severe and the anoxia not too acute or prolonged, thrombosis may not occur. Thrombi may also not appear in the tissue of those burns which are caused by exposing asphyxiated tissue to mild heat, such as 102 F. Under such conditions the similarity of burn and frostbite becomes completely clear. According to this reasoning, the frostbite lesion usually seen and described, relatively, is a burn. In regard to the final question of irreversibility—to continue the speculation—if one accepts the possibility that living human tissue, such as spermatozoa, can survive three hours' exposure at a temperature of  $-269.5^{\circ}\text{C}$ . ( $-453.1^{\circ}\text{F}$ .) or  $-273.1^{\circ}\text{C}$ . [ $-459.6^{\circ}\text{F}$ .] is absolute zero) or forty days at  $-79^{\circ}\text{C}$ . ( $-110.2^{\circ}\text{F}$ .)<sup>27</sup> and that the inferior vena cava of a cat may appear practically normal three weeks after it has been frozen for one minute at a temperature of  $-70^{\circ}\text{C}$ .<sup>28</sup> one begins to question the theory of irreversibility. On the assumption, however, that perhaps when temperatures of tissue are maintained at length somewhere between  $-60^{\circ}\text{C}$ . ( $-76^{\circ}\text{F}$ .)

distinguishes them pathologically from most burns.



TABLE 9.—Mild Rectrification (Therm-O-Rite applicator) for Four Days of a Painful Arthritic Knee

Comment.—H. S., aged 50, suffered from swollen, painful joints, especially the left knee. Her condition was diagnosed as rheumatoid arthritis. The intention in this case was to reduce the pain of the arthritic knee by means of mild refrigeration and to observe other effects of prolonged cooling on arthritic joints. The patient reported complete loss of pain during a few hours, and thereafter a feeling of stiffness in the knee. After four days, during which the cutaneous temperature of the knee was maintained between 60 and 65 °P, because of increased swelling of the knee the refrigeration was discontinued. There were no harmful after-effects. The increased swelling disappeared in a few days.

Certainly the use of cold as treatment of lesions due to reduced temperatures would seem to be well established by its background of Eskimo folklore, the diaries of Arctic explorers, the report of Napoleon's surgeon general after experiencing a Russian winter, the comments of Lake on trench foot in the last world war, the observations of Webster, Ungley, White and others on immersion foot in this war and the recent investigations of Greene, Fay, Allen and others.

Yet, because of and despite this background, it appears necessary to reemphasize the use of cold (cutaneous temperature at 70 F.) as a primary treatment of all types of lesions due

29. Lewis, T.: *Brit. M. J.* 2:869 (Dec. 20) 1941.  
30. Moran, T.: *Proc. Roy. Soc., London s.A* 112:30, 26 (1922:47, 1926.  
31. Plank, R.; Ehrenbaum, E., and Reuter, K.: *Zeitschrift für Volksernährung (Zentral-einkaufsgesellschaft)*, Berlin, 1917, no. 1-27.  
32. Bazett, H. C., in Mock, H. E.; Pemberton, R., and Coulter, J. S.: *Principles and Practice of Physical Therapy*, Hagerstown, Md., W. F. Prior Company, Inc., 35, vol. 1, p. 29.  
33. Blackwood, W., and Russell, H.: *Edinburgh M. J.* 50:385 (July) 1943.

The minimum duration of refrigeration necessary to obtain these temperatures was found to be three hours and when the effect of the tourniquet was added at least two hours.

TABLE 10.—Effect on the Tissue Temperature of Tourniquet Applied Below the Knee for Three and One-Half Hours Without Refrigeration

12/12/12			
Before Tourniquet	3½ Hou Was Applied	Later	
		Room temperature.....	Cutaneous temperature
76	76	98.6	91.5
78	78	93.2	80
80	80	91.5	83.5
83.5	83.5	92.5	90.5
90.5	90.5	92.5	93.25
92.25	92.25	92.5	94.5
92	92	96.5	92.25

Comment.—A tourniquet was applied to the lower part of the leg of W. J., aged 47, as a method of treating a squamous cell carcinoma. This case and the method of treatment is described in another paper, by Dr. Allen. Of interest is the drop of 4 degrees in the temperature of the deep tissue of the calf. The paralysis which followed as effect of the tourniquet, applied for over seven hours, on the leg was anticipated. Within six months normal sensation and control of all muscles had returned.

Tissue temperatures below 50 F. for more than twelve hours may damage tissue when other factors are present. These other factors are (1) certain types of circulatory obstruction (2) slight pressure, and (3) subsequent warming. The last one is possibly most important. Speculative suggestions have been offered (1) regarding the effect of the tourniquet; (2) proposing 70 F. as the optimum average cutaneous temperature for prolonged treatment of burn, frostbite and infection; (3) regarding pathologic effects of cold that seem to justify reduced temperatures as the primary treatment of lesions due to cold.

to cold, whether these are frostbite among employees of the city of New York working at temperatures as low as —20 F.,<sup>32</sup> or of army workers in the Yukon at —75 F. or of high altitude fliers at —62 F.,<sup>30</sup> or immersion foot of sailors marooned in North Atlantic waters at 28 F.<sup>12</sup> or in Mid-Atlantic waters at 70 F.<sup>18d</sup> (where the night air probably lowers cutaneous temperatures of cramped wet feet below 50 F.). Other measures of treatment, such as blocking of the nerves with procaine hydrochloride and heating of the trunk to obtain reflex dilatation in the extremities, are indicated, but from the point of view of the pathologic effect they are secondary.

### CONCLUSIONS

Cutaneous temperatures of 40 to 50 F. and deep muscle temperatures of 45 to 65 F. were found to give satisfactory anesthesia for amputations on the thigh. Slightly lower temperatures were necessary in order to obtain the best refrigeration anesthesia.

35. Brady, L.: Frost-Bite Among Employees of City of New York During Winter of 1933-1934, J. A. M. A. 104:529 (Feb. 16) 1935.

36. It has been suggested by Davis and co-workers that high altitude frostbite is a unique type of cold lesion. Its appearance on the fingers one hundred to one times more often than on the cheek was posed as an inexplicable distinction. Other than the anoxemia, due to high altitudes, and the rapid changes of temperature, due to rapid flights to high altitude and back ground again, allowing little time for compensatory adjustment on the part of the exposed tissues, it is believed that any unique quality of these lesions will be difficult to substantiate. Their predilection for fingers appears no more remarkable than the predilection of arterial vasculature for the extremities, where anatomic and physiologic vascular supply is probably a more important factor than tissue mass per heat-radiating cutaneous surface.

# EFFECT OF EXPERIMENTAL FRACTURE ON BONE DENTIN AND ENAMEL

STUDY OF THE MANDIBLE AND THE INCISOR IN THE RAT

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ST. LOUIS

AND

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Although there are a number of references to clinical aspects of fractures of the jaw (Paderma, 1942<sup>1</sup>; Blair and Ivy, 1936<sup>2</sup>; Padgug, 1938<sup>3</sup>; Major, 1943<sup>4</sup>; Fry and co-workers, 1943<sup>5</sup>; Erich and Austin<sup>6b</sup>) relatively few experimental studies have been reported. Con- tently, in view of present injuries caused by reactions of the jaw to fracture is timely. In particular fractures of the mandible in the growing tooth as well as in the growing e. While fractures of the jaw in dogs or nea pigs have been studied (Schäfer, 1923<sup>7</sup>; ve, 1927<sup>8</sup> and Grimson, 1937<sup>9</sup>), no report the effects of fractures of the jaw in the rat on the simultaneous reaction of all the cal- ed structures present at the site of fracture s found in the literature.

## MATERIAL AND METHODS

This study is based on 38 rats, ranging in age from lateral in 29 animals and bilateral in 9 animals. Department of Histology, University of Illinois Col- e of Dentistry.

I. Thoma, K. H.: Traumatic Surgery of the Jaws, Including First-Aid Treatment, St. Louis, C. V. Mosby npany, 1942.

2. Blair, V. P., and Ivy, R. H.: Essentials of Oral gery, ed. 2, St. Louis, C. V. Mosby Company, 1936.

3. Padgett, E. C.: Surgical Diseases of the Mouth l Jaws, Philadelphia, W. B. Saunders Company, 1938.

4. Major, G.: Fractures of the Jaws and Other al Bones, St. Louis, C. V. Mosby Company, 1943.

5. (a) Fry, W. K.; Shepherd, P. R.; McLeod, C., and Parfitt, G. J.: The Dental Treatment of xillo-Facial Injuries, Oxford, Blackwell Scientific Publications, Ltd., 1943. (b) Erich, J. B., and Austin, a, W. B. Saunders Company, 1944.

6. Schäfer, H.: Ueber die Kallusbildung nach rkieferfrakturen, Schweiz. Monatsbl. f. Zahnh. 33: 7-624, 1923.

7. Greve, K.: Der Heilverlauf von einfachen und mplizierten Unterkieferfrakturen mit besonderer rücksichtigung des Mandibularkanals und der Zähne, utsche Zahnh. 67:1-64, 1927.

8. Grimson, K. S.: Healing of Fractures of the Man- le and Zygoma, J. Am. Dent. A. 24:1458-1469, 1937.

9. Schour, I.: The Effect of Tooth Injury on Other Teeth: I. The Effect of a Fracture Confined to One or Two Incisors and Their Investing Tissues upon the Other Incisors in the Rat, J. Physiol. Zool. 7:304-329, 1934.

*Measurement of the Rate of Eruption.*—The rate of eruption of the incisors was measured by making a horizontal mark with a fine file near the gingival line. With an adjustable caliper provided with fine points, the distance was measured between the point where the marking crossed the distolabial margin of the incisor and the point where the surface of the gingivae crossed the same margin. The distance between these points was measured seven days later. The difference between the two readings represented the rate of incisal eruption for that period.

*Röntgenographic and Histologic Preparation.*—The animals were fixed in a 5 per cent concentration of neutral solution of formaldehyde U. S. P. immediately after death. After the head was severed from the body, a midsagittal section was made to facilitate the roentgenographing of the mandible. Dental occlusal films were used. The further dissection consisted of separating the mandible and preparing it for histologic study. The pieces were washed, decalcified in 5 per cent nitric acid, followed by 5 per cent solution of sodium sulfate, embedded in celloidin and stained with

hematoxylin and eosin or with iron hematoxylin. The sections were mounted in serial order.

NORMAL ANATOMY AND HISTOLOGY OF THE MANDIBLE AND THE INCISOR IN THE RAT

The dentition of the rat consists of one incisor and three molars in each quadrant of the jaws. The incisor is curved, and its enamel and dentin grow and erupt continuously throughout the life of the animal. The molars, however, are of limited growth. They resemble those of man, and their enamel and dentin are completed within the first three months of life. The

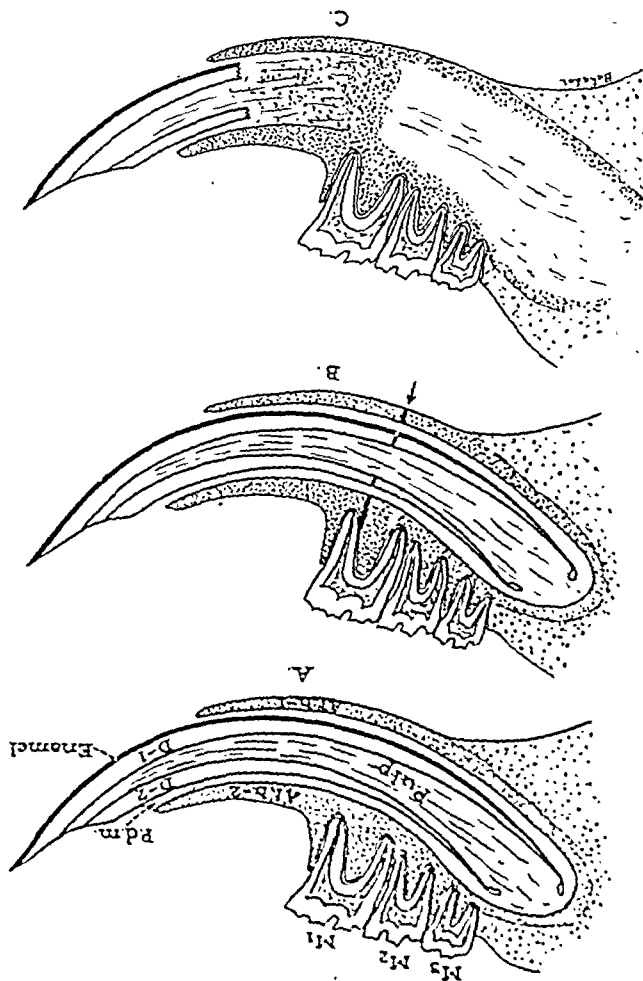


Fig. 1.—Semidiagrammatic tracing (adapted from Schour and Massler<sup>10</sup>) of the portion of the mandible of the rat which contains the incisor and the molars ( $M_1$ ,  $M_2$ ,  $M_3$ ): A, normal structure; B, mandible subjected to fracture at the usual site, indicated by arrow; C, mandible fractured at the same site as in B and showing the forward movement of the anterior fragment, the ankylosis of the posterior fragment and the filling in of the region between the two segments of tooth by bone. Continued activity at the odontogenic zone has resulted in the folding of the recently formed dental tissues. ALB-1, labial alveolar bone; ALB-2, lingual alveolar bone; D-1, labial dentin covered by enamel; D-2, lingual dentin covered by cementum; P.d.m., periodontal membrane.

incisor is situated anterior to the molars in the upper jaw but extends below and beyond the molars in the mandible (fig. 10).

10. Schour, I., and Massler, M.: The Teeth. Griffith, J. Q., Jr., and Farris, E. J.: The Rat Laboratory Investigation, Philadelphia, J. B. Lippincott Company, 1942.

Gross Appearance of the Exposed Portion of the Teeth.—The appearance varied according to

REACTION OF DENTAL STRUCTURES TO FRACTURE

Because of the basic and contrasting differences in the reactions and responses to fracture of the bone and of the tooth, the observations will be described and considered under the separate headings of dental structures and bone.

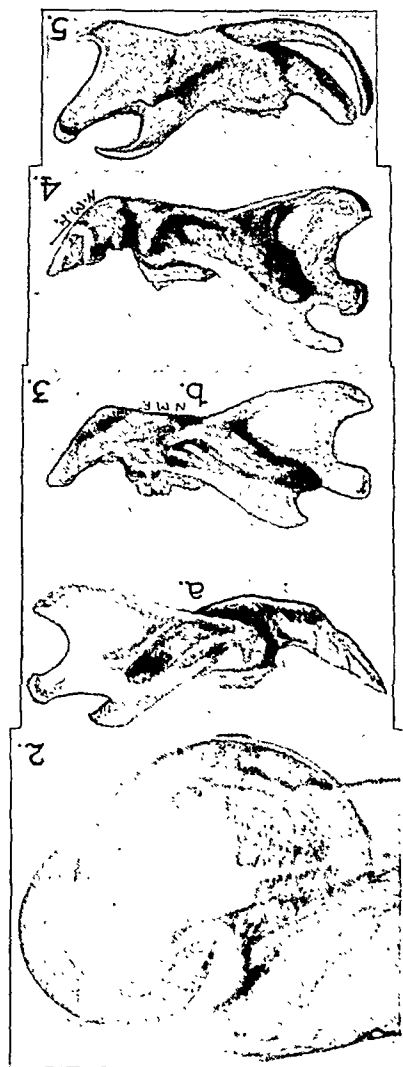
The general health of the experimental animals was, as a whole, normal and paralleled that of the controls. Most of the animals showed an uneventful recovery from the fractures. Occasionally infection was found in the region of injury.

OBSERVATIONS

In the labial portion the labial alveolar periosteum takes the place of the periodontal membrane proper. The fibers run parallel to the long axis of the tooth and fill the region between the enamel epithelium lining the enamel and the labial alveolar plate of bone. This bone is less active and occasionally shows resorption on its inner surface next to the labial alveolar periosteum. The labial bone on the external surface shows an active periosteum with apposition of bone. The bone of the mandible is of endometabrous origin. The reader is referred to an article by Schour and Massler (1942)<sup>10</sup> for a more detailed description of dentition in the rat in normal and in pathologic conditions.

A large proportion of the mandible is occupied by the incisor, and any fracture of the body of the mandible necessarily includes the incisor and its alveolar bone. A fracture of the anterior portion of the mandible in the rat, in a strict sense, is a fracture of the alveolar bone and tooth rather than of the jaw (fig. 14). Figures 14 and 3a show the lower incisor and its position in the mandible. The curvature of this tooth represents a 140 to 145 degree segment of a spiral. It has no root but consists of a long crown. The dentin constitutes the bulk of the tooth and is covered by enamel on the labial, or convex, surface and cementum on the lateral and the lingual, or concave, surface. The tooth is surrounded by fibrous connective tissue and is attached to the surrounding alveolar bone by means of the periodontal fibers. These are embedded at one end in the cementum of the tooth and at the other end in the alveolar bone. The cementum is present only on the lingual (concave) and lateral surfaces of the tooth.

In the labial portion the labial alveolar periosteum takes the place of the periodontal membrane proper. The fibers run parallel to the long axis of the tooth and fill the region between the enamel epithelium lining the enamel and the labial alveolar plate of bone. This bone is less active and occasionally shows resorption on its inner surface next to the labial alveolar periosteum. The labial bone on the external surface shows an active periosteum with apposition of bone. The bone of the mandible is of endometabrous origin. The reader is referred to an article by Schour and Massler (1942)<sup>10</sup> for a more detailed description of dentition in the rat in normal and in pathologic conditions.



Figs. 2 to 5.—Figure 2 is a roentgenogram of the half of the head of rat 1, which was killed one hundred and twenty-three days after the fracture of the left mandible. Histologic sections show a persistence of a cartilaginous callus in the radiolucent area, near radiopaque area at the site of fracture. The anterior segment of the lower incisor was lost, and the posterior fragment erupted into the oral cavity, so that it established a normal incisal relationship. Note the prominent distortion in the enamel and the partial rotation of the pulp in the upper incisor, which showed retarded eruption but was not fractured. Figure 3 is a drawing of the left (a) and right (b) mandible of a rat which lived one hundred and forty-four days after the fracture of the right mandible. Note in b posterior extension of the right incisor to the incisal notch and the absence of the anterior portion of the incisor. Compare with a. Figure 4 is a drawing of the right mandible of rat 73, which lived one hundred and forty-four days after its fracture. Ankylosis at the site of fracture resulted in cessation of eruption and backward growth and accumulation of the posterior portion of the incisor.

(Legend continued in next column)

Figure 5 is a drawing of the dissected left half of the mandible of a rat which lived one hundred and thirty-four days after the fracture of the left mandible. The exposed portion of the incisor perforated the labial alveolar bone and erupted through the cheek. Compare with the normal mandible in figure 3a.  $\times 1.5$

The normal standard with which the rate of eruption of the incisors of the experimental animals was compared was based on one thousand, two hundred and ten weekly measurements obtained from the following sources: (a) one hundred and fourteen measurements taken during the preoperative period; (b) three hundred and forty-three measurements taken from litter-mate controls, and (c) seven hundred and fifty-three measurements taken from normal rats.

**Rate of Eruption.**—The rate of eruption of the injured incisors was retarded in all animals whose mandibles had been fractured. The retardation sometimes appeared within a week, and in some animals eruption stopped completely in a short time.

**Gross Observations on Dissection.**—The mandible showed on gross dissection characteristic disturbances, which varied with the site of fracture, the duration of the postoperative period, and the condition of the anterior fragment. With the increase in the length of the postoperative life there was generally an increase in the size of the buccal protuberance of the incisor at the posterior end of the mandible. In 2 cases this protuberance was situated at the lowest level of the sigmoid notch, instead of at its normal more anterior and inferior position (fig. 3b). In 6 instances the posterior fragment perforated the inferior border of the mandible (fig. 5).

Among those animals which showed a normal incisal relationship (that is, the incisal edges showed bevels which indicated constant normal wear), there were some in which the fractured incisor became ankylosed at the site of injury (fig. 4) and a few in which the anterior fragment was exfoliated while the posterior fragment remained in a fixed position rather than growing forward (fig. 3b). In the latter group, normal functional relationship was made possible because the incisor of the uninjured mandible performed the function of both lower teeth.

the postoperative survival (figs. 3, 4 and 5). In a few of the cases, in which the anterior fragment was exfoliated, the posterior fragment perforated the lower border of the mandible (fig. 3). The uninjured teeth became elongated in many of the animals (fig. 2). In a few animals which were operated on at an early age and had a long postoperative life (ninety-five to one hundred and fifty-seven days), the elongated upper incisors curved inwardly, so that eventually the palate was perforated.

*Röntgenographic Findings.*—Koenigsgenograms clearly demonstrated the site and the extent of the fracture (figs. 2 and 10). A thickening of the alveolar bone was sometimes seen about the site of fracture in animals of a long postoperative survival (fig. 2). The anterior fragment of the tooth was either lost or retained.

In several animals the normal radiolucent pulp cavity was filled in and radiopaque and the width of the periodontal membrane area was increased. Buckling of the tooth in the basal

was replaced by enamel or any enamel-like substance. In the decalcified sections there was often no evidence of fragmented enamel, since the fully calcified enamel was lost in decalcification.

When the site of fracture included the posterior zone where the enamel was still in its early, incompletely calcified matrix stage, the enamel matrix was arrested during the process of calcification (fig. 9). The adjacent enamel blasts were reduced in size, or the entire enamel epithelium atrophied and became replaced by

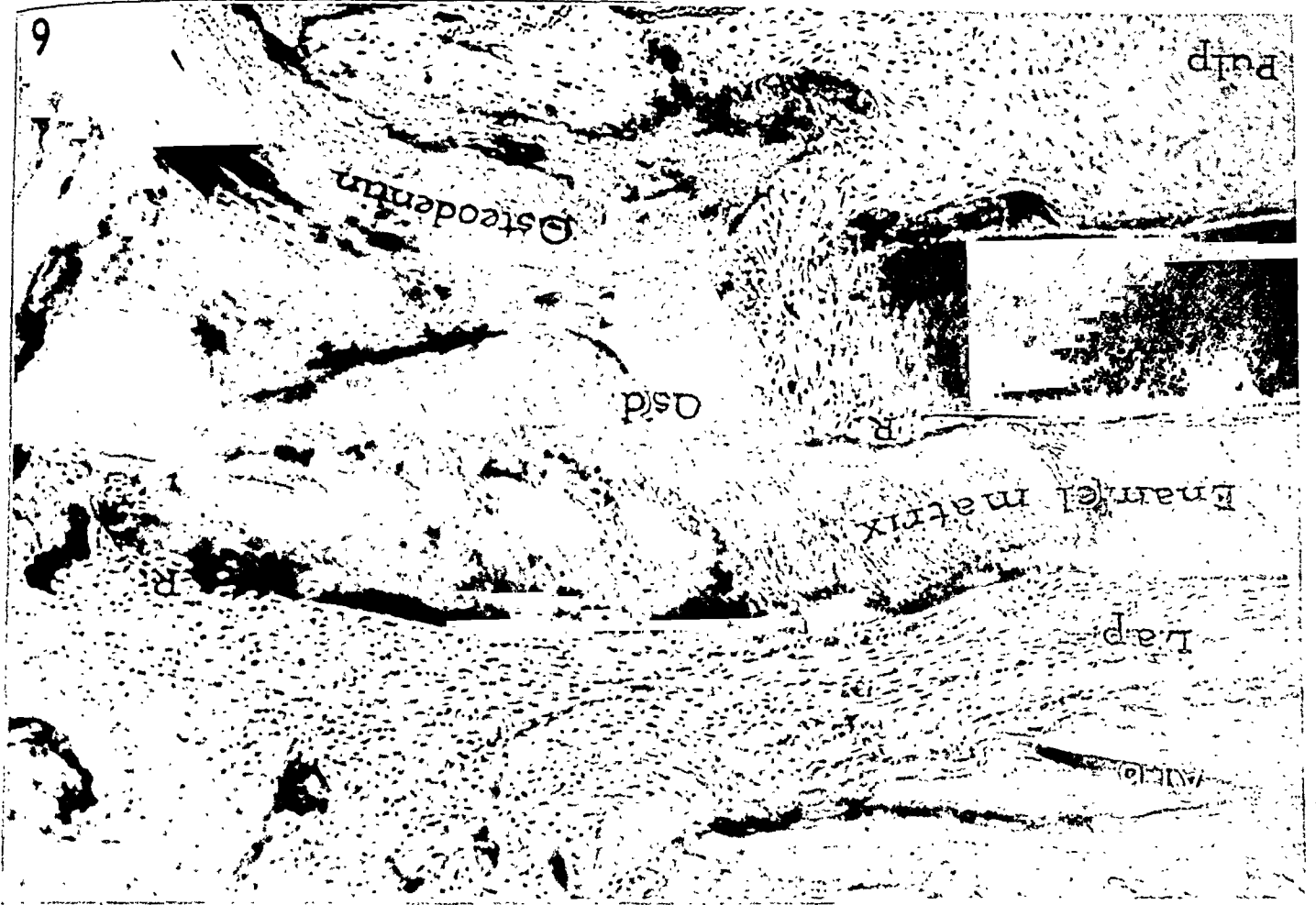


Fig. 6.—Photomicrograph of labial portion of lower right incisor of rat 158, which was killed one hundred and thirty-two days after mandibular fracture. Note the enamel matrix which did not reach complete calcification and which is partially resorbed (R). The enamel matrix also shows invasion of its interprismatic substance by osteodentin (Osd) from the pulp. *Al.b.*, labial alveolar bone; *L.a.p.*, labial alveolar periosteum.  $\times 144$ .

connective tissue. The enamel matrix then became covered by cementum (fig. 7) or was resorbed and replaced by osteodentin (fig. 6). The papillary layer of the enamel epithelium occasionally responded by proliferation, as the distance from the site of injury was increased (fig. 16).

*Odontoblasts and Dentin.*—Either the odontoblasts at the site of fracture were permanently injured, so that formation of dentin ceased (figs. 6, 7 and 8), or they recovered. In the latter case, they deposited a peculiar type of secondary dentin, which was imperfectly formed

area, as a result of crowding and accumulation of the calcified tissues, was common. An additional and unexpected observation was a distortion in the basal structures of the uninjured upper incisors (fig. 2).

HISTOLOGIC OBSERVATIONS

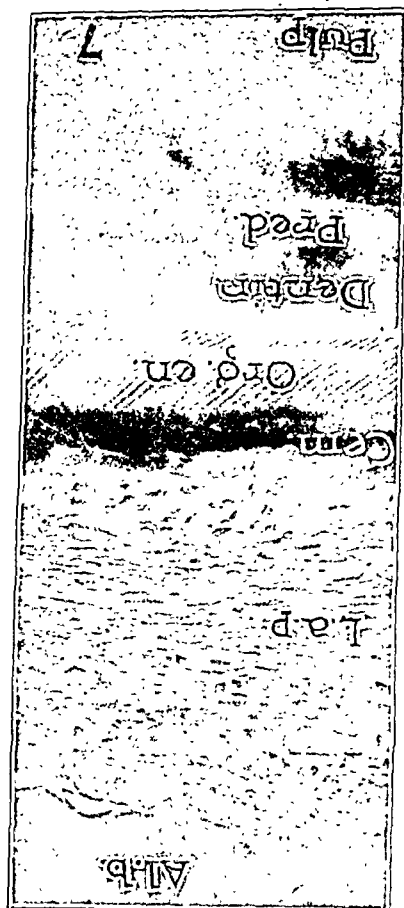
*Enamel Epithelium and Enamel.*—The enamel-forming cells were completely destroyed at the site of fracture. They did not regenerate and were not replaced by adjacent reserve cells, as in the case of injury or destruction of osteoblasts. The result was that no fractured enamel

and calcified (fig. 6). No new generation of odontoblasts arose at the defect caused by the fracture.

The dentin itself showed no reaction to fracture, but there was a sparse infiltration of cells from the pulp and sometimes from the periodontal tissue into the region between the fragments. Eventually a fibrous union occurred between the fragments. Examination may show: (1) complete walling off by connective tissue (foreign body reaction); (2) bridging of the fragments by fibrous tissue without formation of dentin, because of the destruction of the formative cells; (3) partial resorption and replacement by osteodentin; (4) exfoliation.

*Pulp*.—The pulp showed a rich response, which varied with its distance from the site of

Fig. 7.—Photomicrograph of the posterior portion of a midsagittal section of the lower left incisor of a rat which was killed one hundred and twenty-three days after mandibular fracture. Note the organic enamel matrix (*Org.en.*) which remained incompletely calcified and became covered with thick cementum (*Cem.*). The latter replaced the enamel epithelium. This reaction is similar to that seen in rat 166. *Alb.*, alveolar bone; *L.a.p.*, labial alveolar periosteum; *Pred.*, predentin. (Figure taken from Schour, 1934,9)  $\times 175$ .



#### REACTION OF BONE TO FRACTURE

The healing reactions of the fractured bone of the mandible in the rat are generally similar to the healing reactions of bone in other parts of the body and in various species (Urist in 1942<sup>11</sup>).

11. Urist, M. R., and Johnson, R. W.: The Healing of Fractures in Man Under Clinical Conditions. *J. Bone & Joint Surg.* 25:373-426, 1943.

*Basal Zone of Incisor*.—Since the sites of fracture were for the most part in the region of the first molar, direct injury of the basal zone of the incisor did not occur. However, when bony ankylosis developed at the site of fracture and eruption ceased, buckling of the posterior fragment occurred at the formative end (figs. 1C, 3 and 4). This accumulation resulted because the newly forming dental structures at the odontogenic zone, which normally moved forward with eruption, had become crowded at the site of their formation. In such cases there was an actual backward growth of the basal end of the tooth (figs. 3 and 4).

*Periodontal Alveolar Membrane*.—The periodontal membrane occasionally showed an excessive width. Connective tissue from the periodontal membrane frequently grew between the fragments of dentin into the pulp, producing a fibrous ankylosis. At a later stage bony ankylosis occurred (fig. 8).

*Cementum*.—Cementum was frequently deposited on enamel which had lost its epithelial covering and also on splinters of dentin that were implanted in a fibrous tissue (fig. 7).

At six and one-half hours after the fracture there were profuse hemorrhage and an acute inflammatory reaction (fig. 9). Occasionally necrosis occurred (fig. 12). In one instance bone was found within the pulp four days after mandibular fracture (fig. 13). This is an unusual finding. The late reactions of a cyst, with cholesterol fibrosis, formation of a cyst, with cholesterol slits (fig. 8), replacement by bone, with or without hemopoiesis (fig. 14), and amorphous osteodentin, which stains irregularly and deeply with eosin (fig. 6). In spite of these alterations the basal zone of the pulp was as a rule normal and permitted continuous growth of the dental tissues (fig. 12).

In some teeth of animals of longer survival the various pulpal reactions could be seen in the same section, starting with necrosis in the anterior region where the fracture occurred and showing in sequence a zone of acute inflammation, a fibrous walling off and more posteriorly a well vascularized normal pulp.

The normal healing of bone may be considered in terms of the soft tissue reaction and the hard tissue reaction—or replacement by bone proper. Our material will be described from the histologic point of view and for convenience will be described according to the following stages (table 5) :

I. Procallus (hemorrhage, blood clot and organization of clot by granulation tissue) (table 1)

II. Fibrocartilaginous callus (table 2)

III. Bony callus (reorganization and architectural reconstruction of bony callus and bone) (table 3)

which was killed six and one-half hours after the stage of hemorrhage and the formation of the blood clot are well illustrated by rat -



Fig. 8.—Photomicrograph of a mid-sagittal section of the basal portion of the lower right incisor and the mandible of rat 80, killed thirty-five days after mandibular fracture. Note pulp cyst, C, with degenerative products and cholesterol silt; the union of pulpal bone, B, with alveolar bone, Alb., results in a bony ankylosis. The enamel matrix and the dentin are being resorbed at R. P.d.m., periodontal membrane. X 29.

It must be pointed out that these stages are not sharply demarcated but overlap considerably. Since healing is a continuous process, any one fracture may show the predominance of a particular stage but can also indicate phases of the preceding or the succeeding stage.

*Procallus*.—This is the stage of healing from the period of hemorrhage to the formation of young connective tissue. A series of events occurs which is similar to that in the healing of soft tissue in the rest of the body and essentially

A later stage, that of organization of the blood clot into granulation tissue, can be seen in histologic sections of the mandible of rat 137, which was killed three days after the mandibular fracture (figs. 15, 16 and 17). The labial bone



TABLE 1.—(Observations on Fractured Mandibles—Procallus Stage of Healing)

Length of Survival in Days	Age at Death in Days	Roentgenographic Findings	Histologic Observations
2 R	14	Lingual bone fractured superior to first molar	Lingual and labial bone fractured; hemorrhagic fibrin network
4 R	14	Complete fracture; displacement of lingual bone	Fibrin network; granulation tissue; round cell infiltration
4 R	1	...	Early organization of clot
5 R	2	Communion, with displacement of anterior portion of tooth and bone	Large amount of hemorrhage not well organized; fragments of bone
12 R	2	Labial bone fractured in region of third molar	Old hemorrhage; acute inflammation; many fragments of bone
15 R	1	Ankylosis (?)	Hemorrhage and inflammation; many fragments of bone
17 R	1	...	Suppuration and invasion of fibrous tissue into granulation tissue
18 R	1	Incisal absent	Old hemorrhage and infection; no attempt at healing
14 R	16	Irregular radiolucent areas in lingual bone	Sequestrum and infection on lingual surface
17 L	21	Radiolucent area with radiopaque substance on lingual surface	Inflammation and hemorrhage; no healing

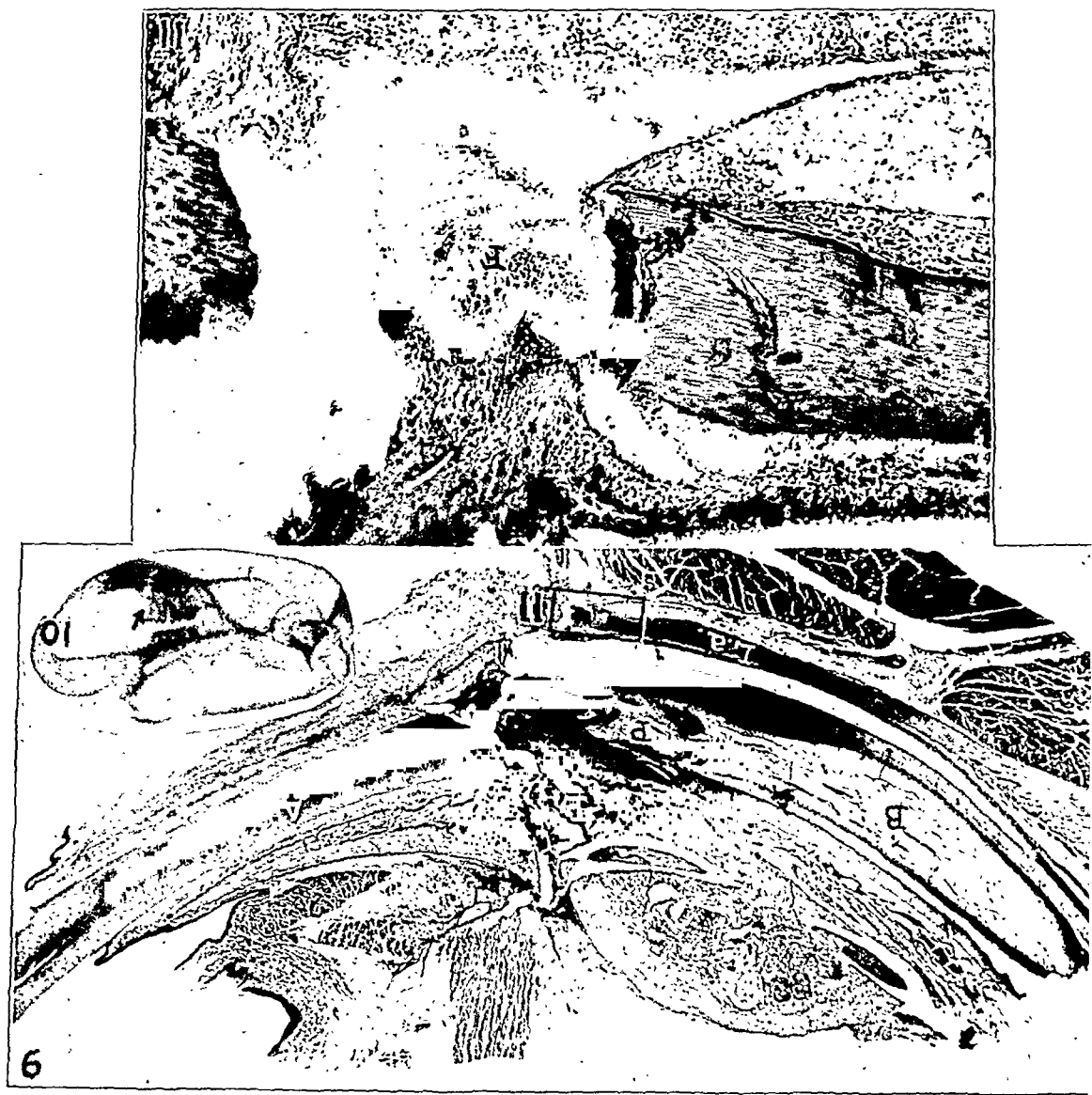
TABLE 2.—(Observations on Fractured Mandibles—Fibrocartilaginous Callus Stage of Healing)

Length of Survival in Days	Age at Death in Days	Roentgenographic Findings	Bone at Site of Fracture	Histologic Observations
61 R	11	Complete fracture with downward displacement of anterior fragment	Old hemorrhage, dead bone and infection	Slight buckling of basal end of tooth; enamel epithelium atrophied
63 R	31	Ankylosis; purulent drainage from mouth	Fibrocartilaginous callus	Fibrous ankylosis; fragments of dentin wall; infection in floor of mouth by connective tissue; inflammation of dentin wall; fibrous ankylosis; buckling of tooth at basal end; bone in pulp; cyst with cholesterol salts in pulp
80 R	35	Ankylosis	Buckling of tooth at basal end	Fibrous callus
83 L	47	...	Lingual fibrocartilaginous callus; labial body callus	...
139 L	56	Ankylosis	Infection at site of fracture	Bone and bone marrow in pulp; infected; hemorrhage with organization of pulp infected; hemorrhage with cholesterol salts in pulp
160 L	60	Purulent discharge; ankylosis 35 days after fracture	Distance between fragments of bone greater than normal	...
161 L	102	Ankylosis; purulent discharge	Bone thickened; buckling of basal end of tooth	Fibrous union; bone thick and rounded; infection in area

TABLE 3.—Observations on Fractured Mandibles—Bony Callus Stage of Healing  
(Rats Arranged According to Length of Survival in Days After Fracture of Mandible)

Length of Survival in Days	Age at Death in Days	Observations	Roentgenographic Findings	Bone at Site of Fracture	Histologic Observations
91 L.	53	Ankylosis	No evidence of bony union	Bony union	Bone and bone marrow in pulp; fibrous ankylosis; fibrous healing of fractured dentin; bone and bone marrow in pulp.
87 L.	55	.....	No evidence of bony union	Bony union	Bony ankylosis; fibrous healing of fractured dentin; bone and bone marrow in pulp.
61 L.	59	.....	No evidence of bony union	Bony union	Bony ankylosis; fibrous healing of fractured dentin; bone and bone marrow in pulp.
64 R.	67	Ankylosis	No evidence of fracture	Bony union	Bony ankylosis; bone in pulp; resorption of enamel; fragments of dentin walling off.
64 L.	67	Ankylosis	No evidence of fracture	Bony union	Bony ankylosis; bone in pulp; resorption of enamel; fragments of dentin walling off.
100 L.	74	.....	Fragments displaced; thick callus; buckling of tooth	Bony union with thick callus	Fracture of tooth at base; part of dentin walling off by bone.
100 R.	74	.....	.....	Bony union	Fracture of tooth at base; part of dentin walling off by bone.
67 L.	81	Ankylosis; no incisal edge	Base of tooth pushed back and buckled; no evidence of fractured bone	Bony union	Fibrous ankylosis; buckling at basal end of tooth; fibrous tissue between fragments of dentin
81 R.	95	Ankylosis; no incisal edge	Base of tooth pushed back and buckled	Bony union	Fibrous ankylosis; buckling at basal end of tooth; cementum on organic enamel matrix
57 L.	102	Ankylosis	Buckling of basal of fractured bone	Bony union	Fibrous ankylosis; buckling at basal end of tooth; cementum on organic enamel matrix
57 R.	102	Ankylosis	No roentgenographic evidence of bony union	Bony union	Fibrous ankylosis; buckling at basal end of tooth; connective tissue between fragments of dentin
82 L.	109	Ankylosis; basal pulged; no incisal edge	Basal end of tooth pushed backward and buckled	Bony union	Fibrous ankylosis; buckling at basal end of tooth; resorption of dentin and enamel matrix
162 R.	109	Ankylosis	Tooth malshaped	Bony union	No evidence of active formation of tooth; fibrous ankylosis of tooth; fibrous ankylosis of dentin by osteodentitis; bone in pulp
86 L.	109	Ankylosis; no incisal edge	Buckling of basal end of tooth; bony callus (?)	Bony union	Basal end of tooth; cementum on enamel; creeping substitution of dentin by osteodentitis; bone in pulp
84 R.	109	Ankylosis	Basal end of tooth high; buckling of tooth; obliteration of pulp	Bone grown across site of fracture	Bone and dentin in pulp; fibrous ankylosis; distortion of enamel and dentin
86 R.	109	Ankylosis	Basal end of tooth high; marked buckling of tooth	.....	Dentin in pulp; fibrous ankylosis; cementum thickened; infection at incisal end; dentitis; marked buckling of enamel and dentin
86 L.	109	Ankylosis	Basal end of tooth high; periodontal membrane and labial alveolar part nearly obliterated	.....	Basal end of tooth; fibrous ankylosis; severe buckling of enamel and dentin; periodontal membrane wide
144 L.	123	Ankylosis	Anterior fragment lost; posterior fragment erupted	Persistence of fibrocartilaginous callus	Cementum thickened
158 R.	132	Buckling of tooth	Buckling of tooth	Bony callus; sequestrums	Ankylosis; buckling of tooth; base; osteodentitis
168 L.	132	Healing of bone; buckling of tooth	Fracture healed	Bony callus	Ankylosis; bone in pulp; buckling of tooth
166 R.	133	.....	Fracture healed	Fracture healed	Ankylosis; connective tissue separates fractured dentin; bone in pulp; buckling of tooth
166 L.	133	.....	Fracture present; severe buckling of tooth	Fracture healed	Ankylosis; connective tissue separates fractured dentin; bone in pulp; buckling of tooth
171 R.	133	Abscess	No evidence of fracture; basal end of tooth high; pulp obliterated; buckling of tooth	No evidence of fracture	Infection in basal third of tooth; buckling of tooth
171 L.	133	Incisor grew through wall (?)	.....	No evidence of fracture	Ankylosis; fibrous tissue with some bone between fragments of dentin
74 R.	144	Ankylosis	Basal end of tooth high; marked buckling; no evidence of fracture	.....	Ankylosis
73 R.	144	.....	.....	No evidence of fracture	Cementum in pulp; late complications in development of tooth
49 L.	147	.....	No evidence of fracture; buckling of tooth	No evidence of fracture	Bony ankylosis; buckling of tooth
79 L.	153	Ankylosis	Fracture present; buckling of tooth; pulp cavity obliterated	Bone healed	Bony ankylosis; osteodentitis; severe buckling of tooth; bone with marrow in pulp

adjacent to the site of fracture shows intense osteoblastic and osteoclastic activity (fig. 16). Fibrocartilaginous Callus and Bony Callus.—(table 2). Cartilage is formed at each side of the fracture and is bridging the gap between the



Figs. 9 to 11.—Figure 9 is a photomicrograph of a decalcified midsagittal section of the lower right incisor of the mandible of rat 2, which was killed six and one-half hours after mandibular fracture. Hematoxylin and eosin stain. Note the fracture which divided the incisor into the anterior (A) and posterior (P) fragments. The fracture is complete and extends from the lingual bone (L)—which is fragmented—across the tooth to the labial bone (L.a.). The pulp (P) shows hemorrhage and acute inflammation. Hemorrhage and fibrin network are seen at the site of fracture. Procallus stage (see fig. 11).  $\times 7$ .  
Figure 10 is a roentgenogram of the right half of the head of same animal as in figure 9. The arrow indicates the site of fracture. Natural size.  
Figure 11 is a photomicrograph of the area indicated in figure 9. Note the fibrin network (F) at the site of fracture of the labial bone and the surrounding inflammatory reaction. Procallus stage.  $\times 107$ .  
formation of fibrocartilage and beginning of callus during the first few weeks. It was during the early part of these stages that the fibrocartilaginous callus was gradually replaced

by bone, and bony union of the fragments was completed (fig. 20). Figure 21 of rat 94, which was killed fifty-three days after mandibular fracture, shows two sites of fracture that have healed by bony union (table 3). In the succeeding months there was an architectural reconstruction of the bone at the site of fracture, with final healing of the bone.



Figs. 12 and 13.—Figure 12 is a photomicrograph of a decalcified midsagittal section of the lower left incisor and the mandible of rat 65, killed four days after mandibular fracture. Hematoxylin and eosin stain. Note the zones of reaction to trauma in the pulp. 1, Fragmented dentin at the incisal edge; 2, zone of necrosis and debris; 3, zone of inflammatory cells; 4, zone of hemorrhage; 5, normal zone. Newly formed bone is seen in the pulp. See figure 13.  $\times 7$ .  
Figure 13 is a photomicrograph of area indicated in figure 12. The bone in the pulp is surrounded by osteoblasts and a rich amount of capillaries. Bone is seldom found in the pulp. In animals which had survived for long periods (sixty to one hundred days) after mandibular fracture there was found an ingrowth of bone. In this instance, however, the bone was present four days after fracture. Its location was a considerable distance from the site of fracture. *Od*, odontoblasts; *Pre*, predentin.  $\times 162$ .



of the fragments of dentin by fibrous tissue sequestrums with local inflammation. There was seldom evidence of bony union.

4. Interposition of foreign tissue, particularly muscle.

5. Infection. In animal 68, in which infection was found clinically (table 2), the histologic picture revealed resorption of bone at the site of fracture, with a heavy infiltration of polymorphonuclear leukocytes.

COMMENTS

*Comparison of Mandible of Rat with That of Other Species.*—The mandible of the rat and the human mandible should not be strictly com-

pared from an anatomic and a physiologic viewpoint. The relative position and the types of teeth, the distribution of bone and the origin and the insertion of muscles differ in the two species. For clinical comparison, the monkey would be a better experimental animal. Fractures of the rat mandible and of the human mandible are probably comparable only on a histologic basis. However, experimental fractures of the mandible in the rat offer a unique opportunity of studying and comparing simultaneously the effects of fracture on the growing bone and the growing tooth, and thus on all the calcified structures in the body.

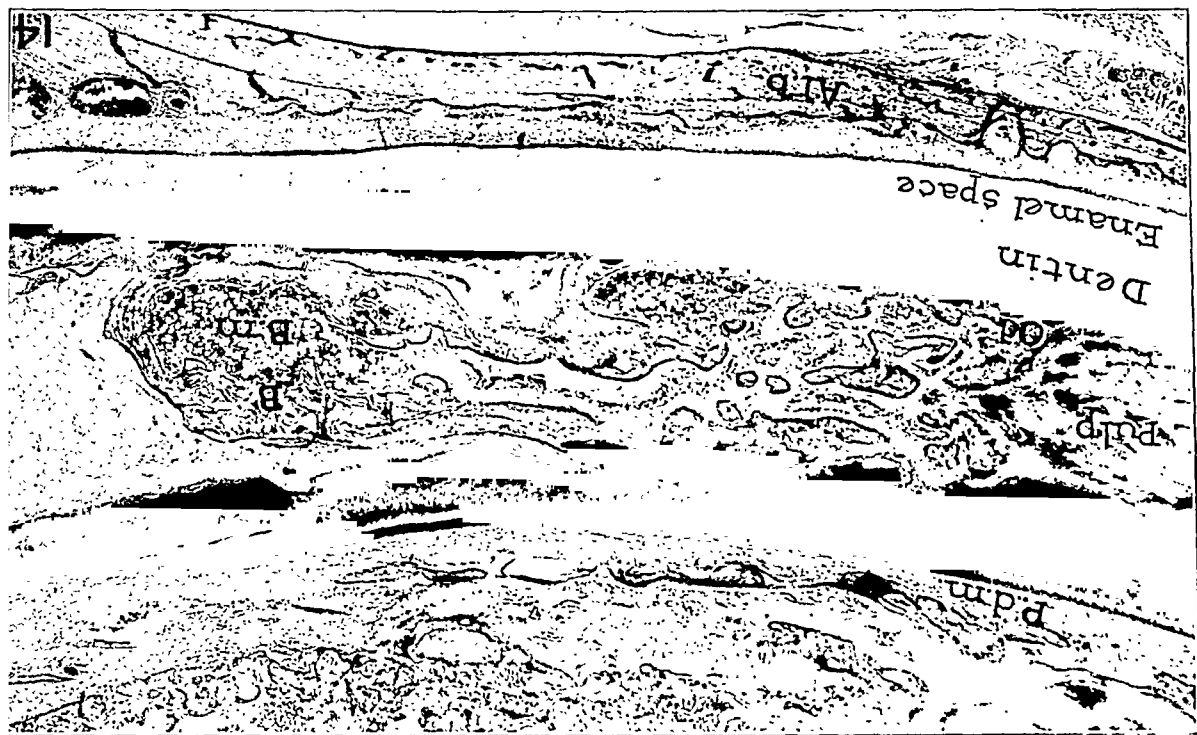


Fig. 14.—Photomicrograph of a decalcified midsagittal section of the basal third of the lower left incisor and bone marrow (Bm) in the pulpal cavity. In some areas the dentin is being resorbed and replaced by bone (Od). Al.b., labial alveolar bone; P.d.m., periodontal membrane. X 29.

delay healing. The initial step toward healing is the formation of an adequate blood clot. Consequently, any factors which tend to retard the formation of the blood clot or to disturb its organization prolong the time required for healing. Frequent causes are:

1. Displacement.
2. Mobility at the site of fracture, often leading to the persistence of the fibrocartilaginous callus.
3. Communion of the mandible, which greatly retarded healing in several instances; frequent fibrous union, with a walling off

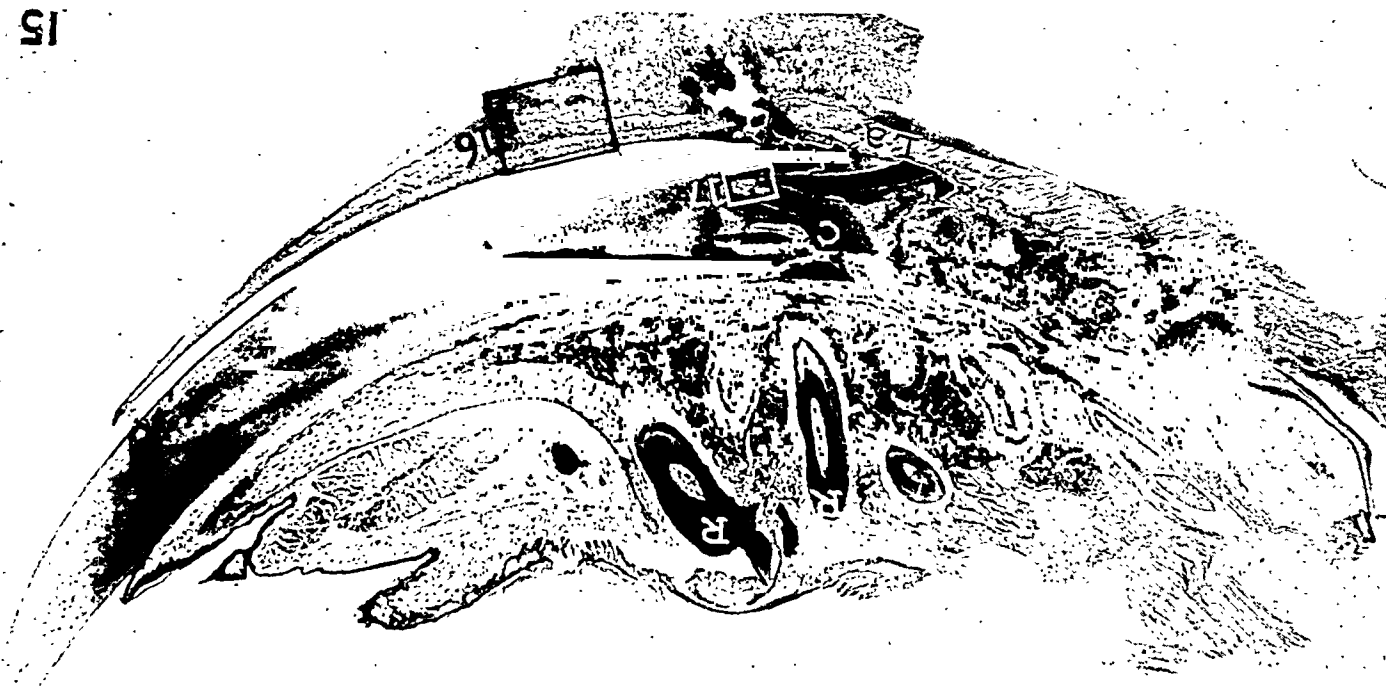


Fig. 15.—Photomicrograph of a decalcified midsagittal section of the lower right incisor and the mandible of rat 137, which was killed three days after mandibular fracture. Hematoxylin and eosin stain. Note at site of fracture comminution of tooth (C), fractured labial alveolar bone (La.) and the roots of molars (R).  $\times 6.5$ .

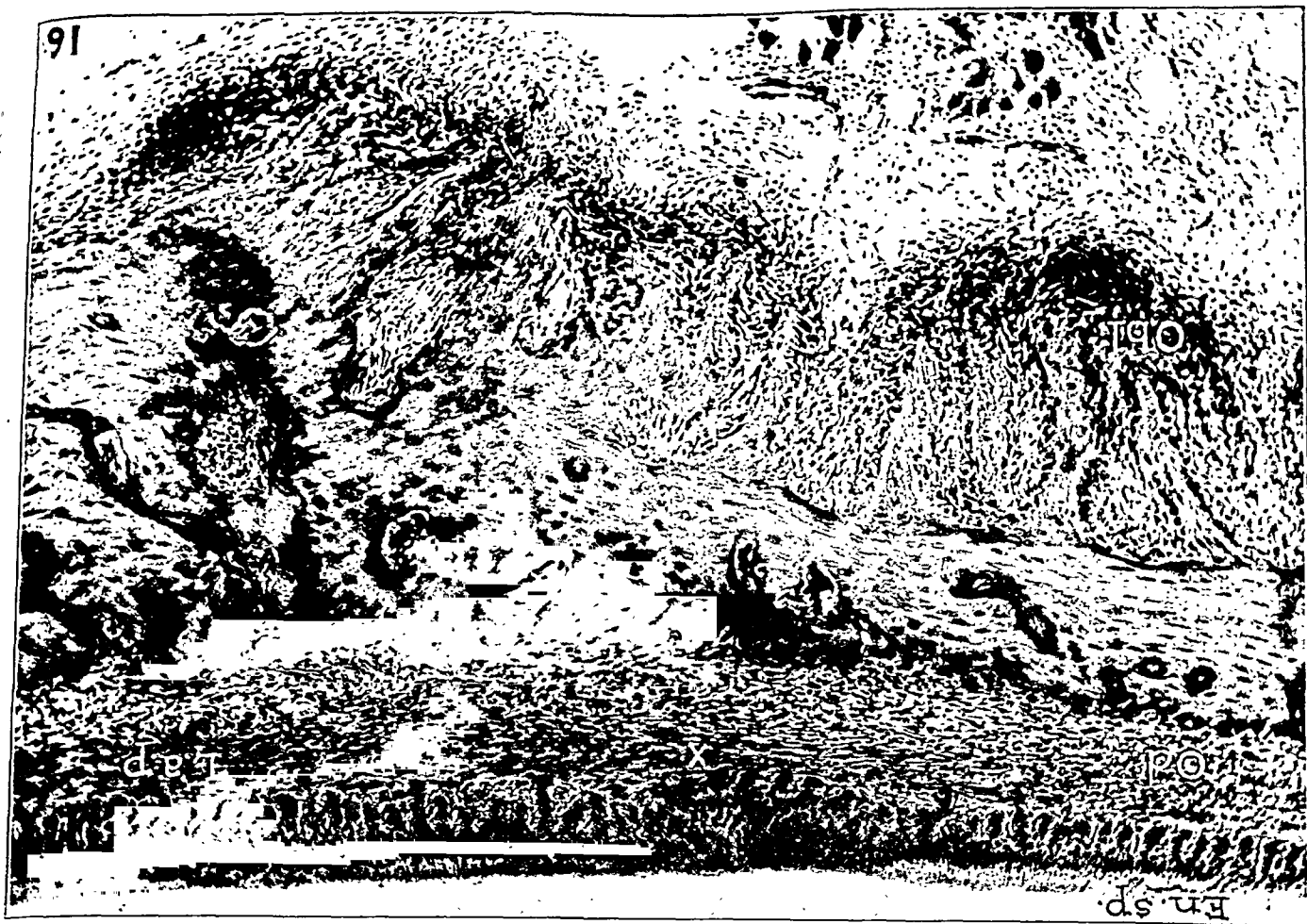


Fig. 16.—Photomicrograph of area indicated in figure 15. Note the intense osteoclastic (Oc.) activity on the lingual surface and the intense osteoclastic (Oc.) activity on the site of fracture. The papillae of the enamel organ have proliferated at X. *En.sp.*, inflamed labial alveolar per-  
osteum adjacent to the enamel epithelium. *En.sp.*, enamel space.  $\times 98.8$ .

*Periodontal Membrane and Ankylosis.*—The tooth is supported in the bony alveolus by the periodontal membrane, and this type of attachment or joint is known as gomphosis. Ankylosis of this joint may occur, as of any other joint. Ankylosis of the continuously growing and erupting incisor of the mandible in the rat is frequently seen as a late complication of fracture. The ankylosis may be either fibrous, with the connective tissue of the periodontal membrane invading the pulp, or bony, with a union of alveolar bone to pulpal bone (fig. 8).

Ankylosis of the tooth, whether bony or fibrous, influences subsequent development of the tooth. The basal or growing part of the tooth is no longer able to grow forward and conse-

*Limited Value of Roentgenograms.*—In our experiments formation of bone was demonstrated histologically during the second month, while roentgenograms did not show healing of bone until about the fourth month. In many animals for which roentgenograms showed no evidence of healing of bone, examination of the histologic sections showed that healing was well advanced. This can be explained on the basis that calcification at the site of fracture is insufficient in amount to be radiopaque. It is well known that bony union can be demonstrated earlier clinically than in roentgenograms. Roentgenograms are valuable in showing the site and the extent of fracture but are of no value in showing early healing of bone.



Fig. 17.—Photomicrograph of area indicated in figure 15. Note the fibrin network and the granulation tissue with leukocytic infiltration.  $\times 305$ .

quently either buckles or grows backward (figs. 3 and 4) along the course of least resistance. The anterior fragment continues to erupt and is finally exfoliated.

*Systemic Effects of Fracture on the Growing Tooth.*—This study is confined to the changes which occur in the tooth and the mandible at the site of fracture. In an earlier report (Schour, 1934<sup>9</sup>), based on most of the same experimental animals, one of us (I. S.) described severe disturbances in formation of enamel and in eruption of the upper incisors (fig. 2) which were

*Comparison Between Healing of Fractures of the Jaw and Healing of Extraction Wounds.*—After dental extraction bone fills the cavity left by the tooth. There is no mobility at the site as in fractures, and the area is more exposed to oral fluids and infection. Healing progresses through the same stages of blood clot, granulation tissue, mature connective tissue, healing of bone and epithelization but proceeds at a faster rate (Hubbell and Austin in 1941<sup>12</sup>).

12. Hubbell, A. O., and Austin, L. T.: Extraction Wounds and Therapeutic Agents: An Experimental Study, J. Am. Dent. A. 28:251-258, 1941.



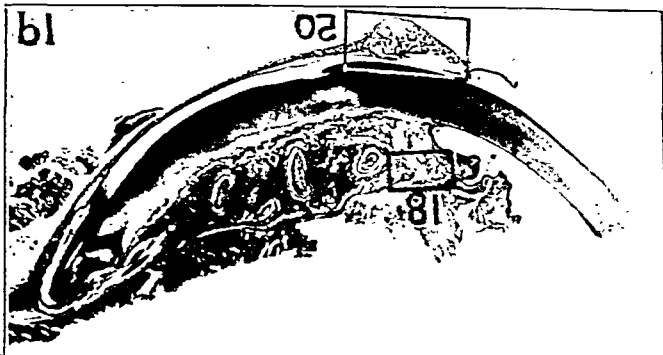
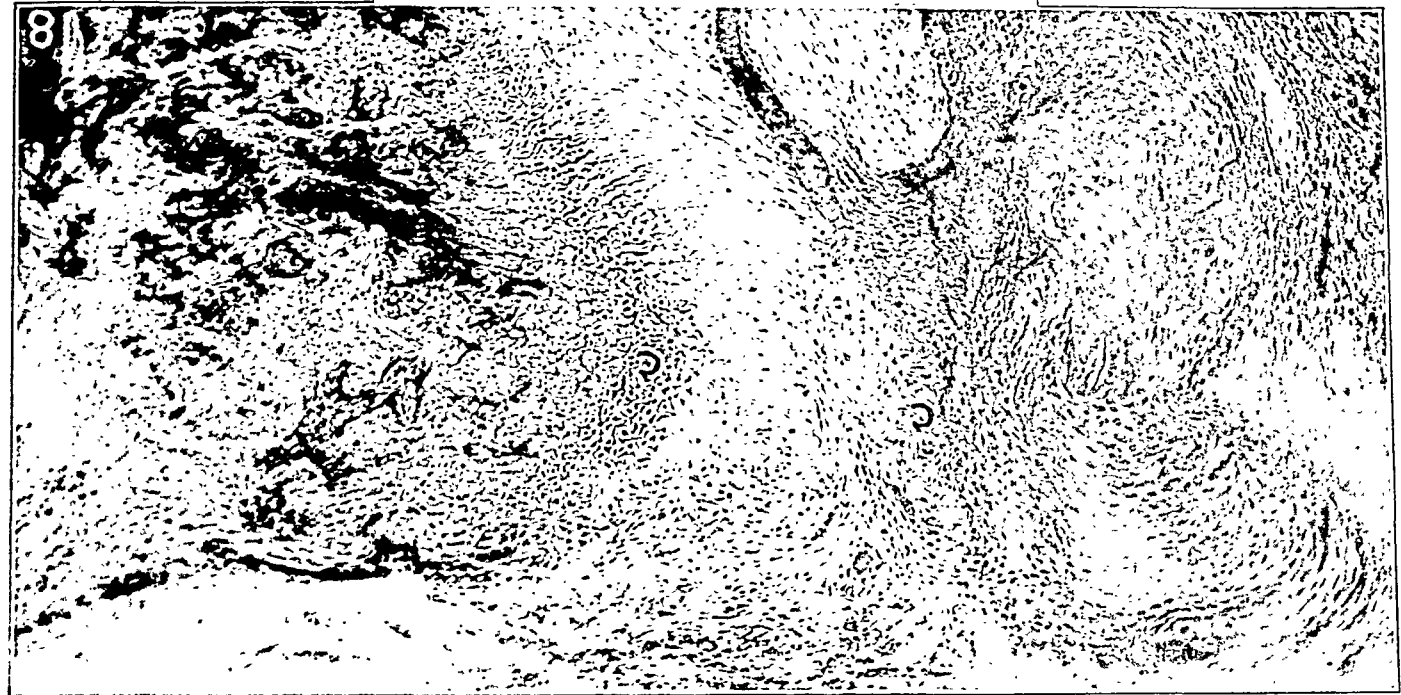
not injured at the time of the fracture of the lower jaw. The only explanation offered was that this distant reaction was systemic. It would be interesting to establish whether a fracture of one bone would cause lines of increased density to appear in the roentgenograms of the other growing bones.

*Differences in Reaction of Various Calcified Tissues to Fracture.*—In contrast to the rich reactivity and response of bone to the injury, dental tissues show little or no reaction in the

the response of bone, enamel, dentin and cementum to fractures.

SUMMARY AND CONCLUSIONS

This study is based on 38 rats, 29 of which were subjected to unilateral and 9 to bilateral fractures of the mandible. The animals were killed from six and one-half hours to one hundred and fifty-eight days after operation. The effects were studied in both the living and the killed animals on gross, roentgenographic and histologic bases. The mandible in the rat con-



Figs. 18 and 19.—Figure 18 is a photomicrograph of area indicated in figure 19. The lingual bone shows a fibrocartilaginous callus at the site of fracture. Note the cartilage cells (C) and the intervening fibrous connective tissue.  $\times 99.6$ .

Figure 19 is a photomicrograph of a decalcified midsagittal section of the lower left incisor and the mandible of rat 58, which was killed forty-seven days after mandibular fracture. Hematoxylin and eosin stain. The effects of the fracture are shown in figures 18 and 20. Note the irregular contour of the tooth. The roots of the molars are cut tangentially.  $\times 3$ .

enamel or the dentin but some active response in the pulp, the periodontal membrane and the cementum.

The fractured tooth changes from an actively functioning organ to one of deformity and dysfunction, while the repair of bone is frequently effective in restoration of normal function. Table 4 summarizes the striking differences in

tains throughout its length a continuously growing and erupting incisor. Consequently, an opportunity is afforded to study the effects of fractures simultaneously on all of the different calcified structures of the body, namely, the growing bone and the growing tooth.

The roentgenograms, with few exceptions, showed little correlation with the stage of histologic repair.



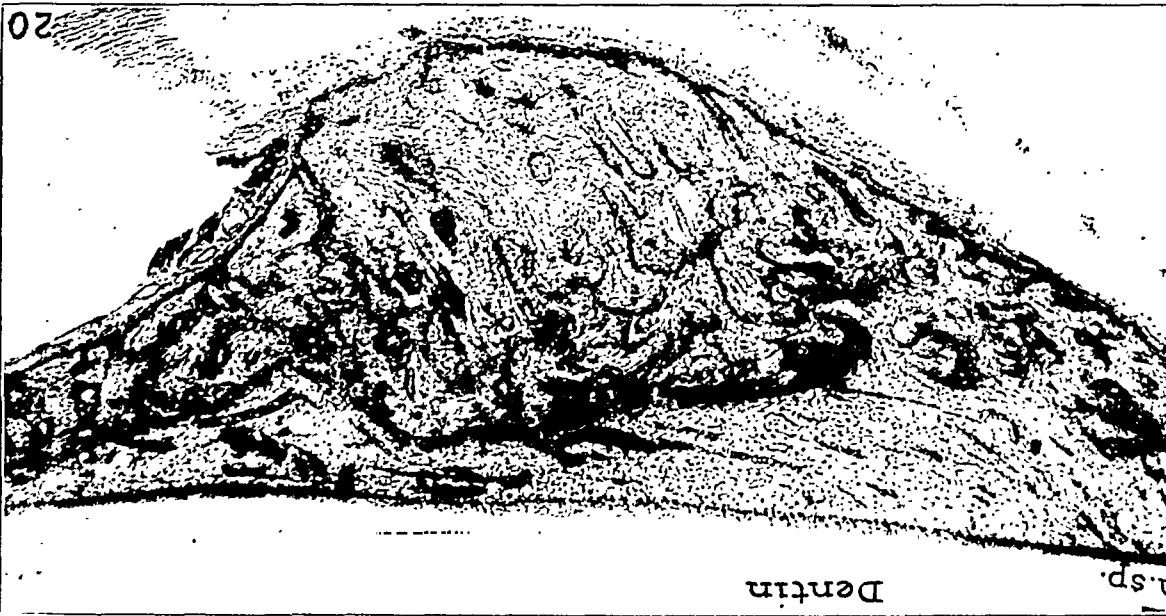


Fig. 20.—Photomicrograph of area indicated in figure 19. The labial bone shows bony union at the site of fracture, with very thick bony callus. *En.sp.*, enamel space.  $\times 50$ .



Fig. 21.—Photomicrograph of labial bone of the left mandible of rat 94, which was killed fifty-three days after tibular fracture. Note bone fragment 1, which was separated by fracture from bone plates 2 and 3, and the union at A and B. Also note the prominent external callus, *Ext.*  $\times 51$ .

TABLE 4.—Comparison of Characteristics and Reactions of the Calcified Tissues

	Enamel	Dentin	Cementum	Bone
Formative Cells	Ameloblasts	Odontoblasts	Cementoblasts	Osteoblasts
Location of Formative Cells	On surface of enamel in stages; absent in adult enamel	Single layer lining the pulp and adjacent to most recently formed dentin	Single layer lining the periodontal membrane adjacent to the cementum	Perosteum; lining of endosteum; haversian canals
Avascular	Avascular	Dentinal tubules; avascular	Canalrill	Canalrill; haversian canals; Volkmann's canals
Response to Injury in (a) Calcifying Stages	Entirely physiol. cap. passive, to metabolic changes; leaving inflammation permanent or regenerate	Incapable of response by leaving inflammation permanent or regenerate	Incapable of response by leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate
Response to Injury in (b) Calcifying Stages	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very active through rich cellular activity along internal and external surfaces of bone
Response to Injury in (c) Calcifying Stages	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very active through rich cellular activity along internal and external surfaces of bone
Response to Injury in (d) Calcifying Stages	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very sensitive to metabolic changes; leaving inflammation permanent or regenerate	Very active through rich cellular activity along internal and external surfaces of bone

*Gross Observations.*—Occasional gross distortions of the mandible consisted of a posterior shifting of the buccal protuberances of the base of the incisor and a perforation of the posterior fragment through the inferior border of the mandible.

*Dental Changes.*—A fractured tooth differs from a fractured bone by the absence of formation of callus and by its limited reaction. The dental structures, by contrast, are for the most part passive and nonregenerative, as follows:

1. Adult enamel reacts only mechanically and is not capable of response by inflammation or repair. The enamel matrix calcifying at the time of fracture is arrested in its calcification and shows resorption. Occasionally it loses its epithelial covering, which then is replaced by connective tissue or cementum.

2. Dentin shows no direct reaction, but the region between the fragments becomes infiltrated by cells of the pulp or the periodontal membrane. The larger fragments are joined by fibrous union.

The odontoblasts are injured, and an atypical secondary dentin is formed in the pulp.

3. The pulp shows a rich and varied response, ranging from necrosis to complete recovery and including the formation of bone and hemopoiesis.

*Healing of Bone (table 5).*—The stages of histologic repair of the fractured mandible in the rat may be summarized in the following chronologic order:

I. Procallus

(a) Hemorrhage and initial blood clot (first few hours)

(b) Organization of blood clot and invasion by granulation tissue (first few days)

II. Fibrous and/or fibrocartilaginous callus (first few weeks)

III. Bony callus (first to second month) and reorganization of bone (first year)

These events are in complete agreement with those occurring in the healing of other flat bones.

# PERITONEAL TAP

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Peritoneal tap affords important and useful data in the management of peritonitis. It was first performed and described by Solomon in 1906. There have been relatively few references to the procedure in the literature since that time. Contributions were made by Panichi in 1912; by Denzer in 1922<sup>1</sup>; by Neuhof and Cohen in 1926<sup>2</sup>; by Cole in 1937, and by Steinberg in a comprehensive paper in 1939.<sup>3</sup> Few of the standard textbooks even mention the procedure. Our interest in peritoneal tap was stimulated when we began an exhaustive study of perforation of peptic ulcers in an effort to reach an early definitive diagnosis by administering methylthionine chloride (methylene blue) by mouth and recovering the dye by peritoneal culture. In a review of 89 cases of perforated peptic ulcer in the eleven years from 1930 to 1941, at the Metropolitan Hospital, McCabe and Mersheimer<sup>4</sup> discussed in detail the diagnosis of perforated peptic ulcer and stated that which perforation existed. This diagnostic procedure was carefully supervised by Dr. Mersheimer, and since his entrance into the naval service we have continued the procedure but have failed to recover the dye in 2 instances. At first employed only in cases of perforated peptic ulcer, peritoneal tap is now being more generally used for a variety of conditions in which it assists in diagnosis and prognosis. Our experience has confirmed the opinion expressed

From the Surgical Service of the New York Medical College, the Flower and Fifth Avenue Hospital and the Metropolitan Hospital.  
Presented at the Graduate Forthright of the New York Academy of Medicine at the clinical meeting of the New York Medical College, Oct. 19, 1943.  
1. Denzer, B. S.: Abdominal Puncture in the Diagnosis of Peritonitis in Childhood, J. Pediat. 8: 41-747, 1936.  
2. Neuhof, H., and Cohen, I.: Abdominal Puncture in the Diagnosis of Acute Intraperitoneal Disease, Ann. Surg. 83:454-462, 1926.  
3. Steinberg, B.: Stages in Peritonitis Based on the Defense Mechanism in Relation to Treatment, Arch. Surg. 89:770-782 (Nov.) 1939.  
4. McCabe, E. J., and Mersheimer, W. L.: Acute Gastrointestinal Perforations: Review of Metropolitan Hospital Series 1930-1941, Am. J. Surg. 62:39-49, 1943.

The technique is therefore simple, and the interpretation of the smears, while demanding rigorous accuracy, is in no way complicated. The procedure, however, is chiefly concerned with the study of the material obtained, and the laboratory data, which must be carefully and accurately recorded, are available in a few minutes. Perforation of the intestine by the needle may occur when adhesions fix the intestine to the anterior portion of the abdominal wall and the surgeon selects that particular area for peritoneal tap, but this is apparently entirely harmless. The point of the needle must be deflected, the lumen proved to be open, the position of the patient shifted and a site for the tap selected where fluid will gravitate

or be available, which obviously in the majority of cases will be in the midline just below the umbilicus. Another site must be chosen if necessary. The amount of fluid withdrawn is immaterial, since a few drops suffices for the smear and the culture.

Steinberg<sup>5</sup> has established the criteria for diagnosis and for prognosis by a study of the exudate obtained, not only by peritoneal tap but through an opening in the abdomen. We desire to call attention to this study, since it is our impression that little notice is generally paid by surgeons to examination of the exudate, probably because of concentration on the clinical factors. The most significant findings are the presence and number of mesothelial cells, their viability or degeneration, the number and types of bacteria, the relative degree of phagocytosis and the presence of extraneous material (particles of food, feces or blood).

In children, peritoneal tap may be readily performed with a 2 inch (5 cm.) no. 20 gage needle and offers valuable assistance in differentiating between peritonitis due to perforating appendicitis, which is so common in children, and other forms of peritonitis, caused by such organisms as streptococci, pneumococci and gonococci. Since surgical operation is urgently indicated in perforating appendicitis and definitely contraindicated in other types of peritonitis, the procedure must be considered of value for a differential diagnosis. Denzer<sup>1</sup> emphasized that, in general, abdominal tap in cases of appendicitis will reveal one of the following: (1) a negative result; (2) a positive result, with no organisms on the smear and a culture which shows either no growth or a pure culture of colon bacilli or a culture of colon bacilli and a strain of coccus; (3) a positive result, with a pure culture of streptococci, which is rare. In pneumococcal peritonitis lancet-shaped diplococci with well marked capsules are recovered in a fluid that is fibrinous, slimy and greenish. In both pneumococcal and streptococcal peritonitis, there is a reduction of phagocytosis and the polymorphonuclear leukocytes are small and few in number (Steinberg<sup>5</sup>). However, one should never depend exclusively on the results of the tap if the weight of evidence establishes a reasonable likelihood that the child has appendicitis, in which case operation should proceed, with disregard for the negative or questionable results of peritoneal tap. In cases of abdominal trauma, peritoneal tap may reveal blood or gross evidence of traumatic

5. Steinberg, B.: Peritoneal Exudate, J. A. M. A. 116:572-577 (Feb. 15) 1941.

rupture of a viscus. While in the majority of cases careful clinical evaluation of the signs and symptoms is usually sufficient to arrive at diagnosis, cases arise presenting confusion, which often leads to delay in diagnosis. In these cases operation may then reveal such significant peritoneal contents that it is certain that peritoneal tap would have furnished evidence indicating early surgical operation, with great benefit to the patient. Wright and Prigot<sup>6</sup> in the review of rupture of the normal spleen, found that the spleen was involved in 47.6 per cent of cases of subcutaneous injury of the abdomen with repeated small hemorrhage in 71 per cent of the cases. They found peritoneal tap to be invaluable aid in the diagnosis of subcutaneous injury of the abdomen. Results of peritoneal tap proved to be positive in 13 of 15 cases of rupture of the spleen. They stated that the finding of blood by abdominal tap indicates intra-abdominal injury.

In 2 of our cases in which there was severe traumatic rupture of viscera, a peritoneal tap although carefully performed, was completely misleading. Peritoneal tap gave positive results in 3 cases which presented diagnostic difficulties especially in regard to determining the need for operation and the location of incision.

In cases of peritonitis, careful evaluation of the history, clinical signs, laboratory data and, especially, roentgenographic findings are in the main reliable criteria as to the cause and afford indications for or against operation. Confusion may often exist, however, because similar evidence of peritonitis will result from diversified causes, especially when distention is associated with rigidity, indefinite tenderness and a high degree of sepsis (weak, thready pulse or chemical imbalance from vomiting, dehydration). Typical examples of confusion arise in the differential diagnosis of perforated peptic ulcer, appendicitis and pancreatitis, of volvulus and mesenteric thrombosis, of rupture of solid viscera and intestine after trauma, with liability of peritonitis when delay supervenes.

Since the factor common to all types of peritonitis is the rapid formation of an exudate, an investigation of this fluid affords valuable information as to the underlying pathologic condition, especially since it is, as a rule, fairly abundant. Careful studies of the pathologic condition associated with peritonitis by Steinberg, by Hertzler, by Collier, Ransom and Rife, by Wright, L. T., and Prigot, A.: Traumatic Subcutaneous Rupture of the Normal Spleen, Arch. Surg. 39:551-576 (Oct.) 1939.



Table 1.—Summary of Twenty-Two Cases in Which Peritoneal Tap Was Done

Name, Sex, Age	Preoperative Diagnosis	Location of Peritoneal Tap	Result	Roentgenogram	Postoperative Diagnosis
J. B., M., 15	Ruptured spleen	Both lower abdominal quadrants	Bloody fluid; no bacteria; many R. B. C.	None	Traumatic rupture of spleen
L. B., M., 36	Ruptured spleen	Right lower abdominal quadrant	Serous sanguineous fluid; no organisms in smear; many R. B. C.; moderate number of W. B. C.; culture negative after 48 hr.	No gas or subdiaphragmatic air present	Laceration and severance of terminal portion of ileum; fecal peritonitis
F. T., M., 65	Ruptured spleen	Lower part of abdomen	Doubtful	Subdiaphragmatic air present	Perforation of duodenal ulcer with peritonitis
J. B., M., 52	Ruptured spleen	Lower part of abdomen	Negative	Subdiaphragmatic air present	Rupture in terminal portion of ileum; tear in its mesentery
J. R., M., 51	Ruptured ulcer; peritonitis	2 in. below and to left of umbilicus	Small amount of sero sanguineous fluid; no methylene blue	None	Rupture in prepyloric region of lesser curvature; ulcer of stomach
J. O., M., 31	Ruptured peptic ulcer	Middle at epigastrium	Dry tap	No subdiaphragmatic air present	Rupture at pylorus on ante floor surface of stomach; lesser curvature; methylene blue seen escaping from rupture during operation
A. R., M., 51	Ruptured duodenal ulcer; methylene blue test	Right upper abdominal and right lower quadrants	From right upper abdomen; final quadrant, negative; from right lower quadrant, clear amber fluid; no methylene blue	None	Ruptured prepyloric ulcer
H. K., M., 51	Ruptured duodenal ulcer; methylene blue test	Lower part of abdomen	Milky white fluid; polymorphonuclear cells with many bacteria	None	Ruptured gastric ulcer
J. S., M., 28	Ruptured duodenal ulcer; methylene blue test	Right lower abdominal quadrant	Methylene blue	None	Ruptured gastric ulcer
T. O., M., 42	Ruptured duodenal ulcer; methylene blue test	Right lower abdominal quadrant	Methylene blue	None	Ruptured duodenal ulcer
A. B., M., 37	Ruptured duodenal ulcer; methylene blue test	Right lower abdominal quadrant	Methylene blue	None	Ruptured duodenal ulcer
C. O., M., 43	Ruptured duodenal ulcer; methylene blue test	Right lower abdominal quadrant	Methylene blue	None	Ruptured duodenal ulcer
M. M., M., 55	Ruptured malignant growth of stomach	Lower part of abdomen	Small amount of sero sanguineous fluid; no methylene blue	Subdiaphragmatic air present	Ruptured carcinoma of stomach
A. A., M., 50	Ruptured bowel	Lower part of abdomen	Feces	Normal	Traumatic rupture of spleen with hemorrhage
F. K., M., 28	Possible intraperitoneal hemorrhage	Left of umbilicus	Dry tap	None	No operation; patient well when released
T. J., M., 54	Diffuse peritonitis	2 in. below and to left of umbilicus	Few drops of brown cloudy fluid; predominant polymorphonuclear cells on smear; neutrophils; many foci of degenerative forms; suspicious colonies of bacteria	None	Laparotomy; abdomen contained 500 cc. of brown fluid; diffuse peritonitis; diverticulis of cecum
A. J., M., 65	Peritonitis	2 in. below and to left of umbilicus	0.5 cc. of cloudy white fluid; smear, 100 per cent neutrophils; many degenerative forms	No subdiaphragmatic air present	Carcinoma of head of pancreas with pancreatitis and peritonitis
C. F., F., 65	Intestinal obstruction; peritonitis	2 in. below and to left of umbilicus	Foul smell; cloudy fluid	None	Perforated diverticulum of sigmoid; local abscess and obstruction
J. M., F., 54	Carcinoma of rectosigmoid with intestinal obstruction	Right lower abdominal quadrant	Feces with <i>Bacillus coli</i> and <i>Bacillus aerogenes</i>	Intestinal obstruction	Carcinoma of sigmoid with gangrene of large bowel and intestinal obstruction
E. C., F., 51	Rupture of stomach; peritonitis	Lower part of abdomen	Doubtful	Subdiaphragmatic air present	Ruptured prepyloric ulcer
E. C., F., 68	Abscess in pelvis	Right of abdomen	5 cc. of faintly turbid fluid; shades of mucus; smear containing many diplococci, short-chained cells, lymphocytes	None	Abscess in pelvis of unde-termined origin
I. H., F., 38	Postoperative adhesions; pancreatitis	Lower part of abdomen	Negative	None	Cholecystitis with adhesions

be accumulated, which should be of decided value in treatment. Peritoneal tap may be accepted as a safe procedure, since penetration of intestine or any blood vessel is almost impossible, but if it occurs no results. We have twice penetrated the intestine, once the cecum and once the terminal portion of the ileum, and both times we obtained fecal material; then we demonstrated at operation a few hours later the site of penetration, which was apparently well sealed by the date. Recent experience with the procedure demonstrated its value in the treatment of operative complication of peritonitis. In 1 patient after cholecystectomy, peritoneal tap relieved the presence of free bile long before we could have recognized a leaking cystic duct as from appendicitis.

In children, the procedure serves to differentiate streptococic and pneumococic peritonitis from appendicitis.

Peritoneal tap is a practical and safe procedure which requires meticulous care in removal of the peritoneal contents and study of the smears and rapid laboratory study, of the peritoneal reaction present.

In children, the procedure serves to differentiate streptococic and pneumococic peritonitis from appendicitis.

# CONCLUSIONS

Information of definite value in diagnosis and treatment in 14 cases (63.6 per cent) and was found to give negative results or to be misleading in 6 cases (27.2 per cent) and to be of doubtful value in 2 cases (9.2 per cent).

TABLE 2.—Results of Peritoneal Tap in Twenty-Two Cases

Diagnosis	No. of Cases	Results of Tap			Total number of cases	Comment
		Positive	Doubtful	Negative		
Peritoneal hemorrhage.....	2	1	1	..	2	Youngest patient..... 28 years Oldest patient..... 65 years Men..... 11 Women..... 1
Forced carcinoma of stomach.....	1	1	..	..	1	Presumption of bleeding; dry tap; recovery without operation
Forced carcinoma of rectosigmoid.....	1	1	..	..	1	Puncture of distended rectosigmoid proved by operation
Intestinal.....	1	1	..	..	1	Puncture of intestine; results of tap misleading; free blood present not recovered
Intestinal rupture of ileum.....	2	1	..	..	1	In 1 case, tap dry but laparotomy showed exudate present
Large abscess.....	1	1	..	..	1	No fluid obtained; scanty exudate present
Perforated diverticulum of cecum.....	1	1	..	..	1	
Total.....	10	7	2	1	10	

While a positive result of a tap is of diagnostic value, a negative result should be disregarded, especially in the face of other diagnostic signs; a negative result indicates usually only failure to obtain fluid which is present.

Peritoneal tap should be reserved for a selected group of cases presenting confusion in diagnosis, and the interpretation of the smear must be painstaking.

In cases in which perforated peptic ulcer is suspected, when diagnostic data are confusing and likely to lead to exploratory laparotomy the recovery by peritoneal tap of methylene blue chloride (methylene blue) previously introduced into the stomach will establish the exact diagnosis.

While the results of the procedure were of definite clinical value in only 62.6 per cent of our 22 cases, the diagnosis in all of these presented great difficulties and could be established accurately only by exploratory laparotomy. The tap in these cases established data that determined diagnosis and aided definitely in treatment as well as in evaluation of prognosis.

In our service at both the Flower and Fifth Avenue Hospital and the Metropolitan Hospital, we have performed about 40 peritoneal taps in the last two years without any complications. A careful study of the procedure was begun in the winter of 1943 in a group of 22 cases (table 1). There were 18 men and 4 women, varying in age from 28 to 65. No patients with suspected appendicitis were subjected to peritoneal tap. Since it is our rule to proceed as directly as possible to immediate operation on such patients, the group of cases in which peritoneal tap was indicated presented difficulties in determining the cause of the peritonitis and required exploratory laparotomy for final diagnosis. Peritoneal fistula and recovery of the patient.

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# ALKALINE AND ACID PHOSPHATASE LEVELS IN THE SERUM OF DOGS AFTER LIGATION OF THE COMMON BILE DUCT

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SAN FRANCISCO

Initial determination of the acid and alkaline phosphatase levels of the serum was made by the method of King and Armstrong on blood withdrawn from the femoral vein. The initial level of alkaline phosphatase for these animals was found to range from 4 to 9 units and that of the acid phosphatase from 1 to 11 units. Four of the animals died within a week after operation, and, while one determination of the phosphatase level was obtained for each of them, they were discarded from the series as inadequate material. The remaining 6 dogs lived from five to fourteen weeks after operation, their phosphatase levels being computed at weekly intervals during the postoperative survival period. Within the first week after obstruction of the common ducts by surgical ligation the alkaline phosphatase levels were found to rise to between 70 and 90 units while the acid phosphatase levels remained at between 2 to 4 units.

After the first week the phosphatase levels either rose gradually or remained essentially the same during the remainder of the survival time, with minor fluctuations, which may be attributed to variations in biochemical technique and fluctuations in photoelectric activity of the colorimeter. At the end of four weeks a cholecystoduodenostomy was done on 2 animals. For 1 of these the phosphatase level, which had already dropped somewhat the third week, progressed at this time gradually downward until it became normal five weeks later, or nine weeks after the initial ligation of the common duct. For the other animal, the phosphatase level rose abruptly after operation for a short period, after which it dropped. It also was normal nine weeks after the initial ligation, or five weeks after the reestablishment of the flow of bile through the gallbladder into the duodenum.

Unfortunately no other concomitant tests of hepatic function were done on these animals except the cephalin-cholesterol precipitation test of Hangar, which within a short time after the initiation of the experiment was found to be unsuitable for dogs. The degree of alkaline phosphatase activity was much greater than could be accounted for by

Use of values of phosphatase activity in the serum as an index of hepatic function was first studied by Roberts,<sup>1</sup> in 1933, who found that there was a marked increase of alkaline phosphatase activity with obstructive jaundice, a slight increase with catarrhal jaundice and no increase with hemolytic jaundice. He stated the belief at this time that, in addition to indicating an increased osteoplastic activity, an increased alkaline serum phosphatase activity might also act as a differential diagnostic measure in some types of hepatic disease.

In 1934 Davies,<sup>2</sup> Bammann and Kriedel<sup>3</sup> found that the spleen, kidneys and liver of swine and cattle contained phosphatases which had optimum activities at two ranges of  $pH$ . One of these was at approximately  $pH$  4.8 and the other at  $pH$  9 to 9.5.

After the original demonstrations of phosphatases with optimum activities at two ranges of  $pH$  in mammalian tissue, interest in phosphatases became centered on cases of malignant diseases. No widespread use of values of phosphatase activity, either alkaline or acid, has been made in the differential diagnosis of hepatic disease, and in order to study this problem and to elucidate further the activity of phosphatases of both alkaline and acid type the following experiment is presented.

Ten dogs were selected from a routine stock, quarantined for two weeks in steam-heated cages and fed the stock laboratory diet utilized at the University of California Medical School; after the two week quarantine the common bile ducts were ligated, with the animals under ether anesthesia. On the day before surgical operation an

From the departments of Pathology and Surgery, University of California Medical School.  
1. Roberts, W. M.: Blood Phosphatase and van den Bergh Reaction in Differentiation of Several Types of Jaundice, Brit. M. J. 1:734-738, 1933.  
2. Davies, D. R.: Phosphatase Activity of Spleen Extracts, Biochem. J. 28:529-536, 1934.  
3. Bammann, E., and Kriedel, E.: Ueber das Vorkommen zweier durch das  $pH$  Wirkungsoptimum unterscheidbaren Phosphoesterasen in tierischen Organen, Ztschr. f. physiol. Chem. 229:125-150, 1934.



CARR-FOOTE—SERUM PHOSPHATASE LEVELS IN DOGS

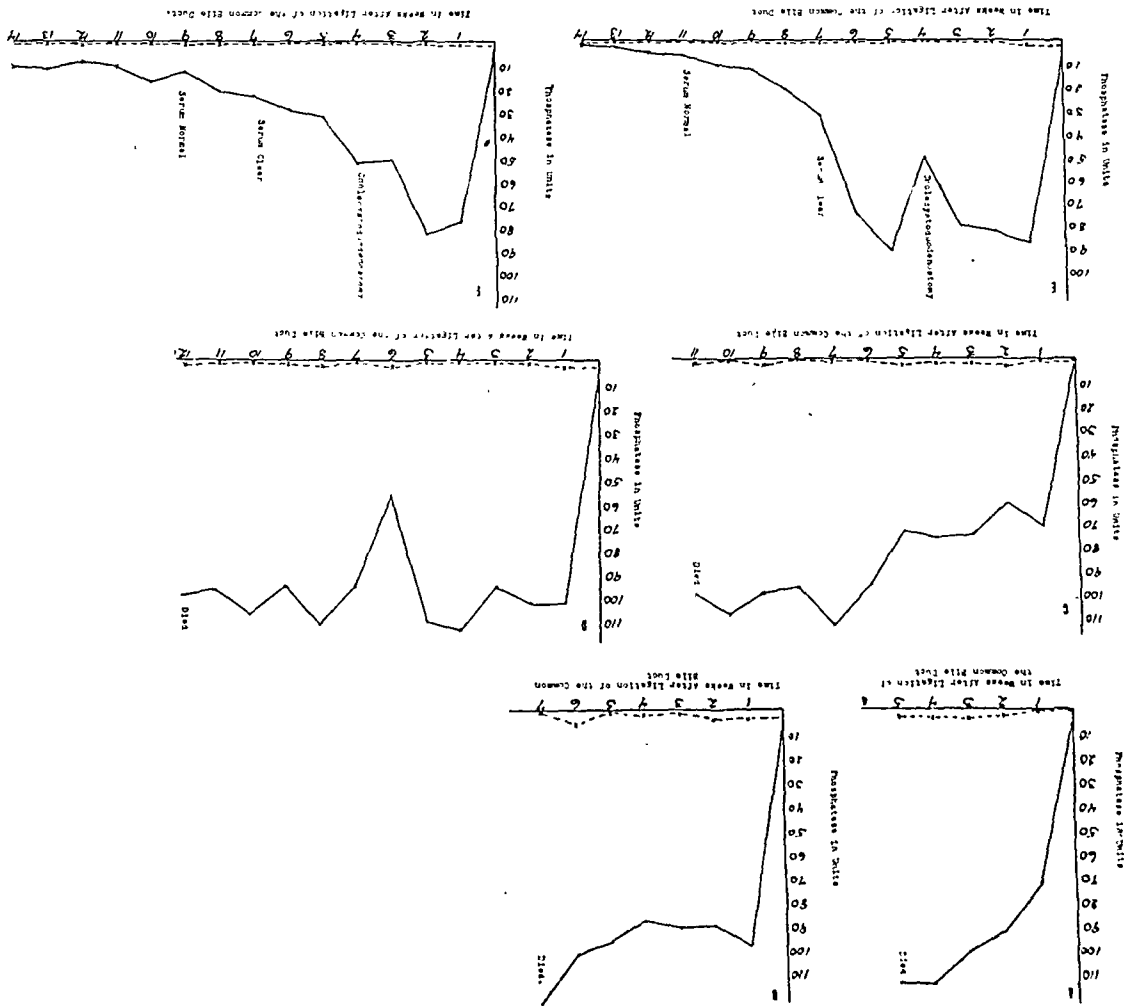


Chart 1—A, serum phosphatase levels for dog 360. B, serum phosphatase levels for dog 402. C, serum phosphatase levels for dog 414. D, serum phosphatase levels for dog 407. E, serum phosphatase levels for dog 415. F, serum phosphatase levels for dog 400. The line of short dashes represents the alkaline phosphatase level. The line of solid dashes represents the acid phosphatase level.

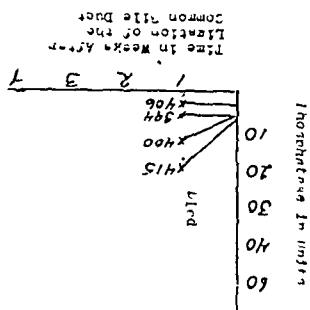


Chart 2—Serum phosphatase levels for dogs 415, 400, 394 and 406. The solid line represents the alkaline phosphatase level.

for by the amount of bile in the blood. It remains consistently high during complete extra-hepatic biliary obstruction until death. On re-establishment of the flow of bile from the gall bladder into the duodenum it gradually declines, lagging appreciably behind the clearing of bile from the serum. The high level represents a delicate and early indication of extrahepatic biliary obstruction and remains throughout the duration of the obstruction. Determination of acid serum phosphatase levels is of no value because they show no variation from normal under such conditions.

The level of alkaline serum phosphatase rises abruptly directly after ligation of the common bile duct and is higher than can be accounted for by the amount of bile observed in the serum after ligation of the duct, and the alkaline phosphatase activity remained above normal two weeks after the serum became clear of bile grossly. (On the other hand, the alkaline phosphatase activity was normal at approximately the same time that the animals were entirely recovered clinically and had resumed their normal habits and nutrition.

CONCLUSION

The level of alkaline serum phosphatase rises abruptly directly after ligation of the common bile duct and is higher than can be accounted

# LOCAL IMPLANTATION OF GELATIN IN WOUNDS

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At the beginning of the present studies we felt that since clinical results indicated that the implantation of gelatin in wounds seemed valuable in promoting more rapid and more stable healing this should be tested in experimental wounds, both in normal animals and in animals reduced by dietary measures to a partially scorbutic state, in which Lanman and Ingalls<sup>2</sup> have demonstrated that wounds show "defective repair of the corium, and a poor production of collagen in the scar." Dogs were found to be included among those animals capable of synthesizing vitamin C and were therefore used in our series of experiments on "normal" animals, which are reported herewith.

## PROPERTIES OF COLLAGEN AND GELATIN

Harrow and Sherwin,<sup>3</sup> in describing the physical and chemical properties of collagen, which is the main organic constituent of connective tissue and of bone, stated:

Collagen is found in the white fibrous tissue beneath the epidermis. The tissue is in bundles separated by a sort of sarcolemma. Interstitial cells, blood vessels and lymph spaces separate the bundles from one another. The size and shape of the bundles vary with the location. In the skin, the bundles are short and thick and cause the "pebbling" of the surface of the skin; while in tendons, the bundles are long and attenuated.

The intimate structure of the collagen bundle is not clear. Probably, it involves a fibrous structure, the fibers being bound into bundles by means of "hulls," connective-tissue cells something like those that surround the nerve fibers. When collagen is converted into gelatin these "hulls" are torn and the fibers are free. Collagen is digested by pepsin-hydrochloric acid to polypeptides, but it is affected by trypsin only at temperatures above 40° C. The tissue "autolytic" enzymes do not hydrolyze collagen at body temperature. Gelatin is produced when collagen is boiled for a time in distilled water. The time necessary to convert collagen into gelatin varies with the kind of collagen. . . .

The authors then stated that a longer time of boiling is required to convert collagen de-

2. Lanman, T. H., and Ingalls, T. H.: Vitamin C Deficiency and Wound Healing, Ann. Surg. 105:616-625 (April) 1937.  
3. Harrow, B., and Sherwin, C. P.: A Textbook of Biochemistry, Philadelphia, W. B. Saunders Company, 1935, p. 694.

This work was undertaken with the idea that the healing of a wound through fibroplasia might take place more readily if substances were supplied locally in adequate amounts throughout the entire healing process, rather than if the body were left alone to supply such substances more slowly. By local implantations in fresh wounds of normal persons, this form of therapy seeks to speed up the healing process and to increase the strength of the wounds so treated.

## THE EFFECT OF GELATIN ON THE HEALING

### OF THE WOUNDS

In emergency operations for dental extraction during the past two years, one of us has implanted gelatin in all operative wounds, with results that seem to justify the treatment. Equal parts of gelatin and sulfanilamide are mixed into the blood before it clots, and usually the wound is closed with sutures. In the beginning only sulfanilamide was used on one side of the mouth as a control. The wounds in which gelatin was also used healed faster and appeared healthier than the control wounds, and no ill effects were observed in any of them. More than 100 wounds have been treated with implantations of gelatin and sulfanilamide. The healing effect of gelatin may be attributed to the excess of preformed collagen provided or to the excess of the essential amino acids which it supplies. The following statements by Lund and Crandon<sup>1</sup> in their discussion of "Nutrition As It Affects Wound Healing" seem to substantiate these assumptions:

The symptoms, signs and gross pathology of scurvy have been long understood. However, the fact that intercellular collagen could not be formed in the scorbutic state is comparatively recent knowledge. Although ascorbic acid has an important intracellular function as an enzyme effective in oxidation-reduction systems, it is the failure of deposition of collagen in its absence that causes failure of healing.

From the Department of Surgery, Vanderbilt University School of Medicine and the office of Dr. J. A. Sinclair.

1. Lund, C. C., and Crandon, J. H.: Nutrition as It Affects Wound Healing, M. Clin. North America 27: 561-563 (March) 1943.

SERIES II.—In series II there were 10 experiments in which strips of skin containing both the gelatinized wound and the control wound were subjected to increasing tensions by suspending weights on the strips (fig. 1). Technical difficulties, such as formation of a hematoma or tension on the wound during excision, may possibly explain the results in these experiments. In 9 of 10 the control wounds ruptured first, and in 1 the gelatin-treated wound ruptured before the control. In the latter experiment the control wound ruptured at 500 Gm. while the treated wound ruptured at 400 Gm. At the other extreme, 1 control wound ruptured at 550 Gm. while the gelatin-treated wound withstood a pressure of 900 Gm. before rupturing. With this severe and critical test 90 per cent of the gelatin-treated wounds easily withstood tensions which ruptured the control wounds.

*Absence of Irritation from Gelatin.*—An observation in all of our experiments, which seems significant, was that signs of irritation or reaction of the tissues to implantation of gelatin were entirely absent. In no single experiment did we note irritative phenomena of any kind. In fact, the gelatin-treated wounds appeared to be drier and to heal with less signs of inflammation than nearby control wounds.

Further evidence of the nonirritative properties of gelatin was furnished by our clinical experience with local implantation of dried sterile powdered gelatin in ulcers.

#### CLINICAL APPLICATION OF GELATIN TO ULCERS ON THE LEG

In order to observe the effect of gelatin on human wounds several ulcers on the leg were selected. In 1 case of recent superficial ulceration on a leg in which varicose veins had been treated, the ulcers were covered with a light layer of finely powdered gelatin and, as usual, elastoplast was wound around the leg so that its adhesive under surface was directly in contact with the gelatin and the wounds. When the bandage was removed, twelve days later, healing was complete and the surrounding skin showed no irritation.

Other series of experiments designed to determine the effect of gelatin on wounds of subcutaneous tissues, of fascia and of tendons and on fractures of bone and a separate series on wounds in guinea pigs reduced by dieting to a subscorbutic state are under way.

#### CONCLUSIONS

Although much of the work on this and related subjects is still in progress, we feel that the following conclusions are justified from results thus far obtained:

1. Implantation of both gelatin and the closely related collagen results in their utilization in experimental sutured wounds in such a way that the strength of these wounds is greatly increased over that of untreated control wounds.
2. Application of gelatin to fresh, open wounds from extractions of teeth and to the soft parts of ulcers appears to hasten the process of fibroplasia and to produce more rapid, stable healing than occurs in similar wounds not so treated.
3. Sulfonamide compounds and gelatin possess no chemical or physiologic incompatibility and have therefore been mixed and implanted advantageously in contaminated wounds.

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LILLIAN EICHELBERGER, Ph.D.

CHICAGO

The family history showed that the patient's father had had blue spots on his lips and had been subject to numerous nosebleeds. Roentgenograms of the parent's chest had revealed some shadows. Other male ancestors in the family were reputed to have had nosebleeds and blue spots on their lips.

**Physical Examination.**—The patient was well developed physically and appeared to be fairly well nourished, although giving the impression of being older than 24. The extreme cyanosis of the lips and the moderate cyanosis of the entire head and neck were pronounced enough to be arresting. The lips had small dark red spots (hemangiomas). Several small hemangiomas were also present on the face. A small ulceration of the nasal mucous membrane was found to be the source of his epistaxis. Otherwise the head and the neck were normal. The fingers and the toes were extremely clubbed and moderately cyanotic. The ankles and the wrists were enlarged and slightly cyanotic. The pulse rate was 70 per minute; the respiratory rate was 16 per minute, and the blood pressure was 110 systolic and 80 diastolic. The temperature was normal. The chest was symmetric, with little abnormality on percussion or auscultation. For a thin person the respiratory sounds were diminished throughout. The heart was normal in size and position, and the tones were normal. Examination of the abdomen, the genitalia and the rectum revealed normal conditions. The extremities had normal strength and range of motion. Sensation and reflexes were intact. The patient was cooperative and of average intelligence. He was definitely concerned about his condition but had become reconciled to the hopelessness of the prospects of improving it.

**Laboratory Findings.**—1. The red blood cells numbered 7,200,000 per cubic millimeter and the white blood cells 6,600, and the hemoglobin content was 23 Gm. per hundred cubic centimeters. The total blood volume was 12,750 cc., of which the plasma volume was 2,420 cc. and the cell volume 10,330 cc.<sup>2</sup> 2. The urine was normal. 3. The vital capacity of the lungs was 3,800 cc. 4. Roentgenograms of the chest showed a lobulated, moderately opaque area covering about 25 sq. cm. located between the left seventh and ninth ribs posteriorly. A second similar opacity, 1 cm. in diameter, was seen in the midaxillary line at the level of the right sixth rib. Roentgenograms of the extremities revealed the formation of considerable periosteal new bone from the bones of the forearm and leg distalward.

From the preceding data three conditions were considered in the differential diagnosis: (1) pulmonary fibrosis; (2) arteriovenous shunt in the lung (in view of the circumscript lesions of the lungs a shunt through an arteriovenous aneurysm seemed most likely; the poly-

## REPORT OF A CASE

R. R., a white man 24 years old, entered the University of Chicago Clinics on Jan. 24, 1943, complaining of frequent nosebleeds and colds over the last two or three years. He also had suffered from generalized cyanosis and clubbing of the fingers and toes for at least sixteen years.

At the age of 6 years the patient had an attack of influenza, soon after which the clubbing of the fingers and the cyanosis were noted. Throughout the past two years he had been inconvenienced by a mildly productive cough, which was aggravated when he was lying on the left side. The man had worked as a farm laborer prior to the past year but had never been incapacitated by his physical condition.

From the Departments of Surgery and Medicine of the University of Chicago. This work was done in part under a grant from the Douglas Smith Foundation for Medical Research of the University of Chicago.

1. Hepburn, J., and Dauphinee, J. A.: Successful Removal of Hemangioma of Lung Followed by Disappearance of Polycythemia, *Am. J. M. Sc.* 204:681, 1942.

2. Shenstone, N. S.: Cavernous Angioma, in *Medical-Surgical Tributes to Harold Brunn*, Berkeley, Calif., University of California Press, 1942, pp. 503-507.

cythemia was thought to be secondary); (3) congenital cardiac disease. The patient was admitted to the hospital for further study. Bronchoscopy showed the mucous membrane of the larynx, trachea and bronchi to be dull red and chronic.

Other analyses are shown in table 2.

TABLE 1.—*Hemangioma of the Lung*\*

Author	Age	Sex	Comments	Physical Findings	Blood	Outcome
1. de Lange, C., and de Vries Robles, S. B.; Zisch, L. Kinderh. 34: 304, 1923	2.5 mo.	..	None related to lungs	Autopsy—two pulmonary tumors; capillary hemangioma	Unknown	Died
2. Wollstein, M.; Arch. Path. 12: 562 (Oct.) 1931	4 mo.	..	..	Autopsy—malignant hemangioma	Anemia	Died
3. Hall, E. M.; Am. J. Path. 11: 343, 1935	10 yr.	F	..	Malignant hemangioma	Anemia	Unknown
4. Bowers, W. F.; Nebraska M. J. 21: 55, 1936	2 days	..	Pulmonary hemorrhage	Autopsy—hemangioma	Unknown	Died from hemorrhage
5. Rhodes, C. B.; J. A. M. A. 110: 1914 (June 4) 1935	25 yr.	M	Dyspnea, cyanosis, pulmonary hemorrhage	Clubbing of fingers and toes; cyanosis; pulmonary opacities	Polycythemia, hyperhemoglobinemia	Died from hemorrhage
6. Duvoir, M.; Pictet, G.; Pollet, L., and Gaultier, M.; Etude clinique, Bull. et mêm. Soc. méd. d. hôp. de Paris 55: 696, 1930	12 yr.	..	Dyspnea	Pulmonary opacities	Normal	Died of pneumonia
7. Smith and Horton <sup>12</sup> ...	47 yr.	M	Cyanosis, dyspnea on exertion, weakness, vertigo, tinnitus	Cyanosis, clubbing of fingers and toes	Polyemia, polycythemia, hyperhemoglobinemia	Unknown
8. Hepburn <sup>1</sup> and Dauphine <sup>2</sup>	23 yr.	F	Dizziness, dyspnea, clubbing of fingers	Cyanosis, clubbing of fingers, pulmonary opacities	Polyemia, polycythemia, hyperhemoglobinemia	Pneumothorax well
9. Goldman, A.; Dis. of Chest 9: 479, 1943	22 yr.	M	Cyanosis, clubbing of fingers and toes	Cyanosis, clubbing of fingers and toes; pulmonary opacities	Polyemia, polycythemia, hyperhemoglobinemia	Living
10. U. of C. Clinics 1942	21 yr.	M	Epistaxis, cyanosis, clubbing of fingers	Cyanosis, clubbing of fingers and toes; pulmonary opacities	Polyemia, polycythemia, hyperhemoglobinemia	Pneumothorax well

\* Case reports of hemangioma of the lung. The lesions described in reports 5, 7, 8, 9 and 10 were cavernous and had produced a compensatory polycythemia, polycythemia and hyperhemoglobinemia.

TABLE 2.—*Status of the Blood Before and Following Total Pneumonectomy for Cavernous Hemangioma (Arteriovenous Fistula) of the Left Lung*

Date	Therapy and Comments	Red Blood Cells, Millions	Hemoglobin, Gm.	Hematocrit, per Cent	White Blood Cells	Blood Volume
2/8/43	Vital capacity 3,800 cc. (venous section)...	7.2	23.0	82	8,500	Total volume 12.7 Plasma volume 2.4 Cell volume 10.3
2/10/43	700 cc. blood removed	..	..	..	..	..
2/11/43	Pneumonectomy intrapleurally, 2,400 cc.	..	..	..	..	..
2/11/43	600 cc. plasma intrapleurally, 2,400 cc.	5.05	15.5	62	7,000	Total volume 6.90 Plasma volume 2.68 Cell volume 4.22
2/12/43	Blood loss at operation 2,200 cc. + 800 cc. plasma intrapleurally	5.10	16.5	63	..	..
2/13/43	plasma intravenously	..	..	61.5	..	..
2/15/43	..	6.04	17.0	51.5	8,700	Total volume 6.90 Plasma volume 2.68 Cell volume 4.22
2/18/43	..	5.10	15.0	53	9,800	..
2/20/43	..	5.12	16.0	54	10,700	..
2/23/43	..	..	..	..	..	..
2/25/43	..	4.94	17.0	52	11,700	Total volume 6.90 Plasma volume 2.68 Cell volume 4.22
3/12/43	..	5.33	17.5	..	12,300	..
3/26/43	..	5.42	17.5	..	8,400	..
4/23/43	Vital capacity 2,200 cc.	5.49	17.7	..	7,900	..
5/21/43	..	5.16	16.7	..	10,600	Total volume 6.90 Plasma volume 2.68 Cell volume 4.22
11/22/43	Working	5.05	15.7	54	..	..

In view of these findings an arteriovenous shunt chiefly in the left lung, was thought quite likely, and the patient was prepared for an exploratory operation by the removal of 700 cc. of blood by venesection.

cally congested. A moderate amount of tenacious secretion was removed. An electrocardiogram was normal. The oxygen content of the venous blood was 22.48 volumes per cent and the oxygen capacity 34.5 volumes

eration.—With the patient under ethylene-oxygen anesthesia (introduced under mild positive pressure through a snug-fitting face piece) the left pleural cavity entered through the sixth rib bed. The apex of the r lobe of the left lung posterolaterally was attached re parietal pleura over an area 4 by 5 cm. by ex-

smaller lesions with similar characteristics were noted in the upper lobe of the left lung. A pneumonectomy was therefore thought advisable. The left lung was resected, a technic of individual ligation being used. The vessels were doubly ligated with linen, and the bronchus was closed with two rows of chromic catgut sutures, those of the proximal row being of mattress

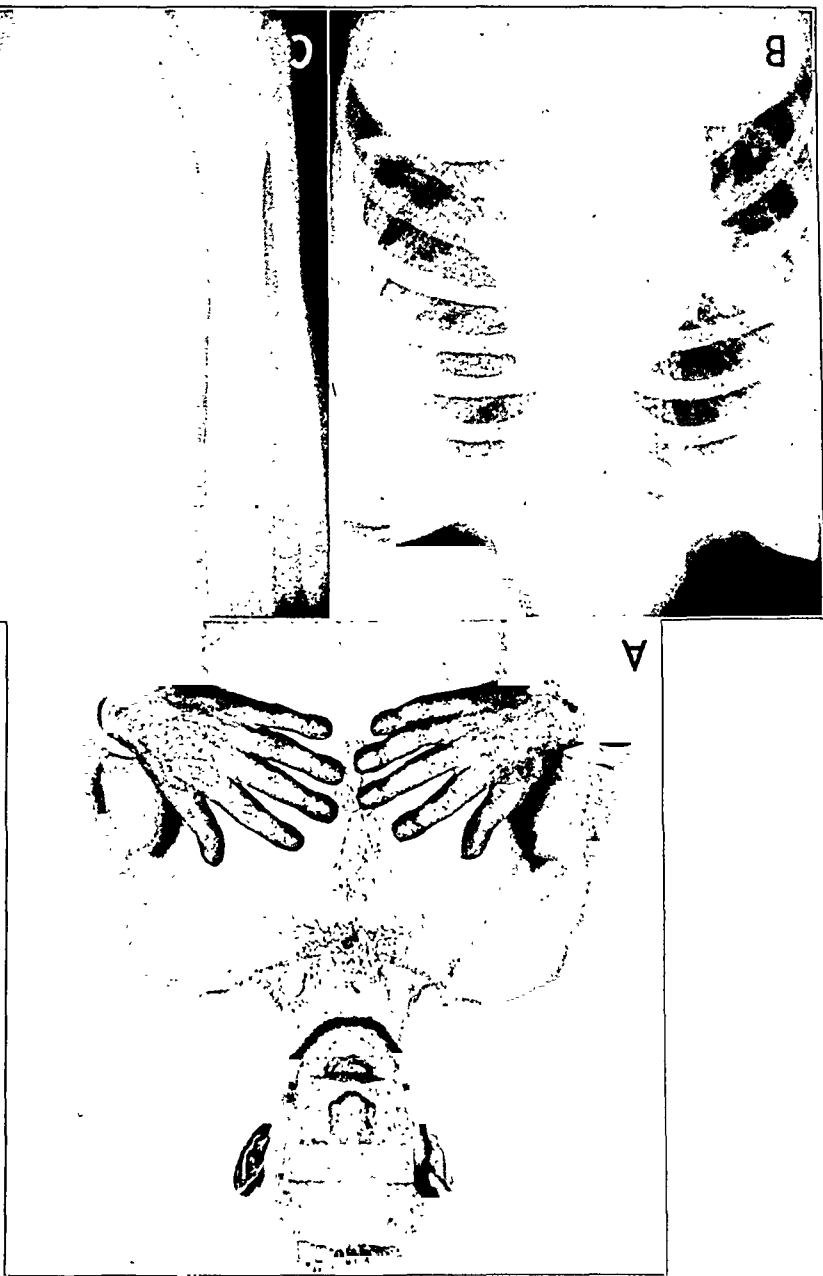


Fig. 1.—A, photograph of the patient, showing distinct clubbing of the fingers and cyanosis of the hands and the ce. Several small hemangiomas are present on the patient's lips. B, roentgenogram of the chest, showing an cm. in diameter is barely visible in the third interspace anteriorly near the wall of the chest on the right side. C, roentgenogram of the lower extremities, revealing extensive formation of periosteal new bone and sclerosis of the long bones.

at were visible and palpable on the pulmonary surface covered by the adhesions. This area could be depressed anually and would refill immediately on release of ressure; hence it was obviously an aneurysm. Two

type. After the hilus was dusted with crystals of sulfathiazole, the wall of the chest was closed in layers without drainage. After closure of the pleural cavity air was removed and replaced with 600 cc. of plasma.

The intrapleural pressure was reduced to a normal negative pressure at the end of this procedure. During the operation the blood which had been lost was partially replaced by 2,400 cc. of plasma given intravenously. This was somewhat less than the 2,200 cc. of blood lost at the operation plus the 700 cc. removed by venesection.

**Reaction During Operation.**—The blood pressure, the pulse rate and the respiratory rate remained almost constant throughout the operation, the blood pressure being 110 systolic and 70 diastolic at the beginning and 100 systolic and 60 diastolic at the end of the operation, two and one-half hours later. The cyanosis, which was extreme at the beginning of the operation, did not disappear immediately when the pulmonary artery was clamped (as observed by Hepburn and Dauphine in



Fig. 2.—Photograph of the left lung with the largest of the three aneurysms opened. The arterial and venous communications are labeled.

their patient), but it improved within a period of thirty minutes and continued to do so during the operation.

**Pathologic Specimen.**—On the surface the lobes of the lung appeared normal except for the three areas seen to pulsate at the time of operation. The pleura over the largest of the three (in the lower lobe) was thickened. In a cut section after fixation this presented a multi-located, smooth-lined cavity, measuring 3 by 4 cm, which communicated with the pulmonary artery through a vessel 4 to 5 mm. in diameter and with the inferior pulmonary vein through a channel 1 cm. in diameter. The two areas in the upper lobe measured 1 to 1.5 cm. in diameter. They were similar to the cavity in the lower lobe but communicated with the lesser circulation through very small vessels. Microscopic sections showed these cavities to be lined by mesothelial cells lying on a fibrous connective tissue wall. There was no hem-angiomatous tissue outside of the cavities.

**Diagnosis.**—Multiple arteriovenous fistulas of the lung.

**operative Course.**—There were no serious complications following the operation. Administration of

sulfathiazole was begun the day before operation. At for seven and fifteen days respectively following the operation. Intranasal inhalation of oxygen (8 to 1 liters per minute) was used for the first few days. The patient's temperature was elevated to 100 to 101 F. for one week, after which it returned to normal. The patient experienced some difficulty with mucus but was relieved by inhalation of steam. Most of the remaining air in the left pleural space was removed on the day following the operation and replaced by 300 cc. of plasma. The patient also received 800 cc. of plasma intravenously.

Immediately after the operation the red cell count and the hemoglobin content were markedly altered (red blood cells fell to 5,000,500 and hemoglobin to 15.5 Gm. per hundred cubic centimeters). The values fluctuated during the subsequent seven to ten days but remained within relatively normal limits thereafter. The patient's color remained somewhat of an ashen gray for several weeks following the operation but has now (one year postoperatively) become more nearly normal. He was discharged from the hospital three weeks after the operation and returned to work two months later. At infrequent intervals the patient has returned to the out-clinic for examination and studies on his blood. The results of these studies are presented in tables 2, 3 and 4. Tables 3 and 4 present data on the concentration of electrolytes, water and proteins in serum and whole blood and the values of oxygen for arterial and venous blood before and following pneumonectomy. These findings will be given in detail in order to characterize the pathologic physiology produced by this type of pulmonary lesion.

Venous blood was withdrawn without stasis. Oil portion was transferred to a tube containing oil, in which it was dehydrated for analyses of whole blood; the remaining portion was transferred to a tube containing oil and allowed to clot, and the serum was removed and analyzed. The samples of venous and arterial blood for determination of oxygen content and capacity were taken in tonometers, neutral potassium oxalate being used as the anticoagulant.

The following determinations were made: on serum  $pH$ , carbon dioxide, water, protein, nonprotein nitrogen, chloride, sodium and potassium; on dehydrated whole blood, cell volume, water, chloride, sodium and potassium and on oxalated arterial and venous blood, oxygen content and capacity and carbon dioxide. **Chemical Methods.**— $pH$  was determined with the glass electrode, and total serum carbon dioxide, blood oxygen content, oxygen capacity and carbon dioxide content were determined by the methods of Van Slyke and Neill.<sup>4</sup> Determinations of water content were made by drying known weights of serum or blood to constant weight at 100 C. Analyses for chlorides were carried out by the Wilson and Ball modification<sup>5</sup> of the method of Van Slyke.<sup>6</sup> Sodium was determined by the Butler-4 Van Slyke, D. D., and Neill, J. M.: Determination of Gases in Blood and Other Solutions by Vacuum Extraction and Manometric Measurement, J. Biol. Chem. 61:523, 1924.

5. Wilson, D. W., and Ball, E. G.: Study of Estimation of Chloride in Blood and Serum, J. Biol. Chem. 79:221, 1924.

6. Van Slyke, D. D.: Determination of Chlorides in Blood and Tissues, J. Biol. Chem. 58:523, 1923-1924.



mill method<sup>9</sup> and potassium by the method of Shohl and Bennett.<sup>10</sup> The proteins were determined by the micro-kjeldahl method of Campbell and Hanna,<sup>11</sup> dis-  
tillation of the ammonia being carried out in the modified apparatus of the micro-kjeldahl distillation apparatus. The proteins were estimated by multiplying by 0.25 the nitrogen corrected for the nonprotein nitrogen. Tables 3 and 4 give the analytic and derived data on blood before the operation and at intervals following the removal of the lung. It will be noted that the removal of the blood previous to the removal of the lung must be the result of an anoxia brought about by malformation of blood vessels, causing a large proportion of blood to be shunted from the right to the left side of the heart without being oxygenated.

TABLE 3.—Concentrations of Electrolytes, Water and Proteins in Serum and Whole Blood  
Analytic and Derived Data

[illegible]

TABLE 4.—Values of Oxygen for Arterial and Venous Blood

Arterial			Venous			Date	
Proportion of O <sub>2</sub> Hemoglobin per Cent	O <sub>2</sub> Tension, Mm.*	O <sub>2</sub> Lost by Blood in the Tissues, Vol. per Cent	Proportion of O <sub>2</sub> Hemoglobin per Cent	O <sub>2</sub> Content, Vol. per Cent	O <sub>2</sub> Capacity, Vol. per Cent	Before operation 2/10/13	After operation 2/11/13
95	80	4.2	74	14.80	50.60	Normal blood	Normal blood
87	45	7.34	54	13.32	24.62	11/22/13	11/22/13
88	55	8.95	43	10.92	22.31	5/21/13	5/21/13
72	58	8.60	35	8.18	22.55	4/2/13	4/2/13
71	37	9.80	33	9.23	24.70	2/11/13	2/11/13
			63	22.30	55.54	2/10/13	2/10/13
			41				
			26				
			18				
			32				

*Analyses of Serum.*—Analyses of the serum before the operation showed that this type of anoxia produced a light alkalosis, which in turn influenced slightly the concentration of sodium in the serum. The acid-base balance is important in anoxia, since changes in this balance affect the respiratory center and also the disso-

10. Armstrong, H. G.: Principles and Practice of Aviation Medicine, Baltimore, Williams & Wilkins Company, 1939, p. 289.
11. McGuarrre, I.; Ziegler, M. R.; Stone, W. E.; Wangenstein, O. H., and Dennis, C.: Studies on Mechanical Insulin Convulsions: Effects of Varying Partial Pressures of Atmospheric Oxygen and Carbon Dioxide in Adrenalectomized Animals, Chinese M. J. 58:26, 1940.
12. Shohl, A. T., and Bennett, H. B.: A Microchemical Method for Determination of Potassium as Iodoplatinate, J. Biol. Chem. 78:643, 1928.
13. Campbell, W. R., and Hanna, M. I.: Determination of Nitrogen by Modified Kjeldahl Methods, J. Biol. Chem. 119:1, 1937.

hemoglobin in the arterial blood is 95 per cent saturated with oxygen, or by chemical analyses it contains 19 volumes per cent of oxygen. As the blood passes through the capillary bed, approximately 5 volumes per cent of oxygen is taken by the tissue and approximately 14 volumes per cent of oxygen or hemoglobin remains in the arterial blood, which gave a normal per cent of oxygen in the lung the following removal of the lung. It is important that the water content and the concentrations of protein in the serum were normal before removal of the lung. Three months following removal of the lung the serum was 7.43 and the total carbon dioxide content was 26.92 millimoles per liter, which gave a normal

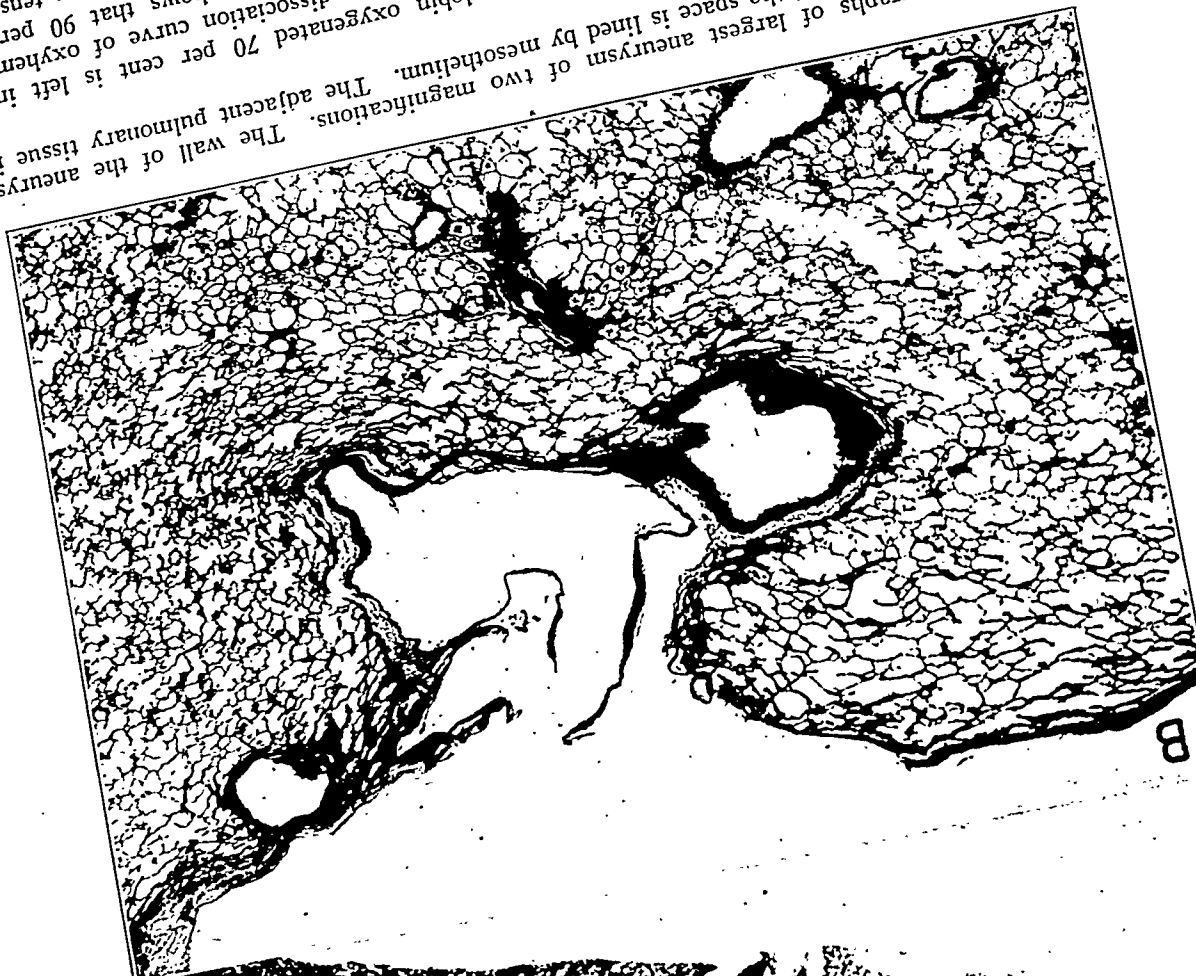
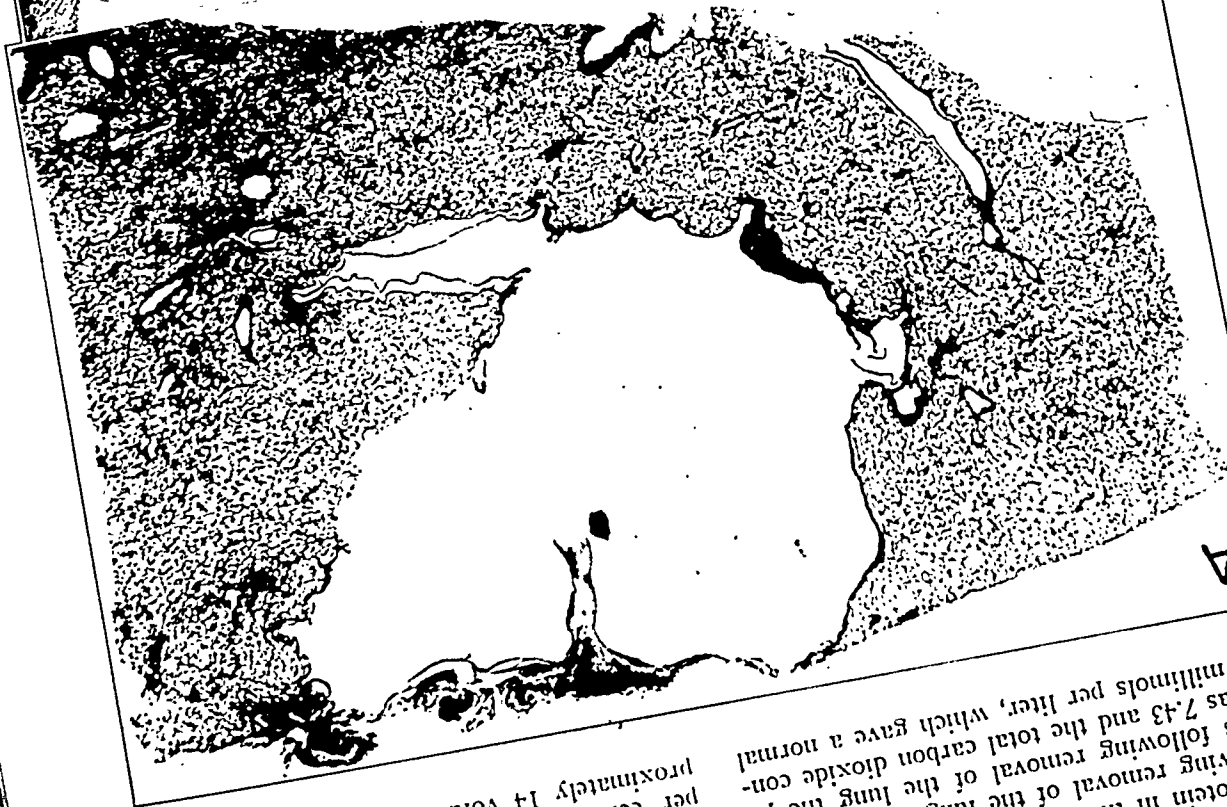


Fig. 3.—Photomicrographs of largest aneurysm of two magnifications. The wall of the aneurysm contains considerable connective tissue, and the space is lined by mesothelium. Also, carbon dioxide tension, of 41 mm. of mercury. At this partial pressure of oxygen the

*Analyses of Blood.*—At normal atmospheric pressure of 760 mm. of mercury, oxygen exerts a partial pressure of 159 mm. At this partial pressure of oxygen the

amount of oxygen present in the arterial blood of this saturation corresponds to an oxygen tension of 40 mm. of mercury. It will be noted from table 4 that the dissociation curve of oxyhemoglobin from blood. The dissociation curve shows that 90 per cent oxygen is left in the venous blood. The adjacent pulmonary tissue is normal. globin oxygenated 70 per cent is left in the venous blood. The dissociation curve of oxyhemoglobin from blood. The dissociation curve shows that 90 per cent oxygen is left in the venous blood. The adjacent pulmonary tissue is normal.

subject was greater by 5 volumes per cent than that found in normal persons. The reason for this is the determined abnormally large cell volume, of 82 per cent. This is important, but it is more important for the oxygenation of hemoglobin that the oxygen be applied at a definite pressure. Before operation, in the arterial blood the oxygen tension was 37 mm. of mercury and the proportion of

the tissues. If this gradient of pressure is reduced, the tissues are not supplied adequately with oxygen and the rate of oxidation in the tissues is diminished. In our patient before operation this was true. After removal of the lung, the arterial oxygen tension was increased 20 mm. of mercury, causing an increased gradient of pressure between the blood capillaries and the tissues, which resulted in more oxygen being lost to the tissues

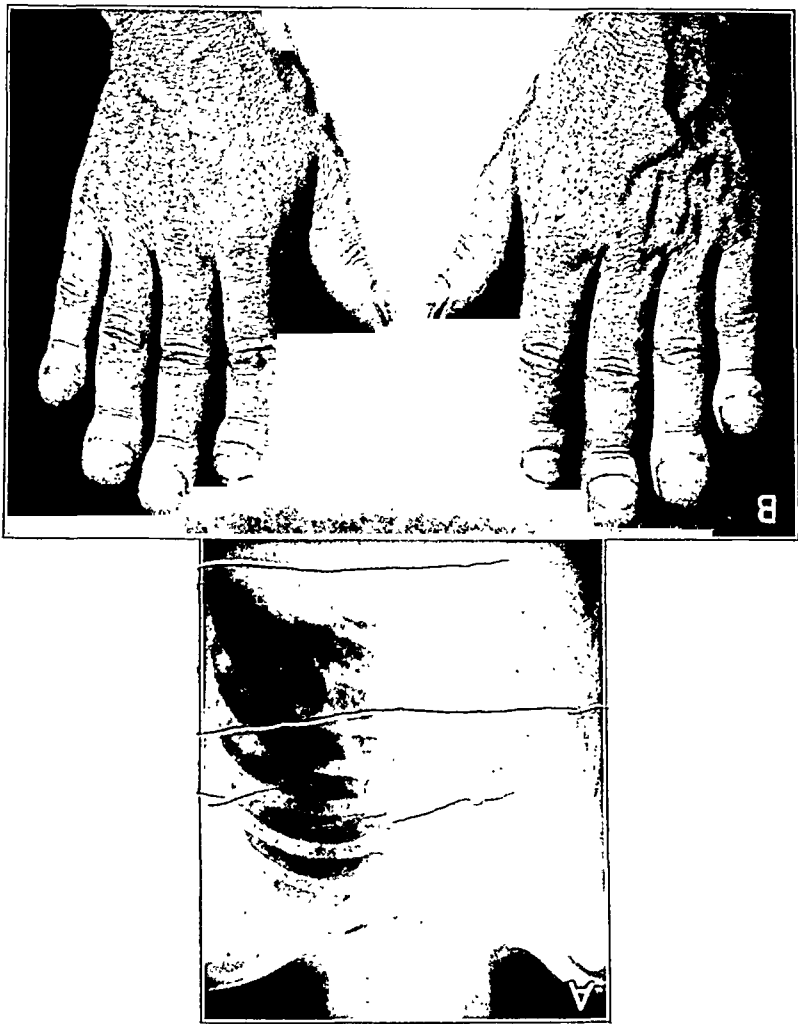


Fig. 4-4, roentgenogram of the chest taken after total removal of the left lung. *B*, photograph of the patient's hands approximately five and one-half months following pneumonectomy of the left lung. Note the dark transverse lines across the nails of the fingers and thumb. These lines have been moved distalward after the excision of the lung and probably represent metabolic changes produced by its removal.

hemoglobin oxygenated was 71 per cent; in the venous blood the proportion of hemoglobin oxygenated was 63 per cent and the oxygen tension was 32 mm. of mercury. Following the removal of the lung, the proportion of hemoglobin oxygenated in the arterial blood mounted to 85 to 88 per cent and the oxygen tension was 60 mm. of mercury; in the venous blood the proportion of hemoglobin oxygenated fell to 48 to 54 per cent, with an oxygen tension of 26 mm. of mercury. Normally the oxygen is carried to the tissues at a relatively high pressure, so that there is a considerable gradient of pressure between the blood capillaries and

Most authors who have reported cases similar to the one here presented have described the lesion as a cavernous hemangioma. A careful study of the microscopic sections made from the specimen removed from our patient reveals only normal pulmonary tissue surrounding the three separate mesothelium-lined cavities found in the left lung. On the basis of the pathologic picture, the lesions are really arteriovenous aneurysms or fistulas. It is possible that owing to the

#### COMMENT

increased pressure, the hemangiomatous tissue may have been broken down and obscured by the connective tissue in the wall of the cavities. The case reported by Smith and Horton<sup>12</sup> suggested that this course of events might have occurred simultaneously with the increase in size of the communication between the pulmonary artery and vein. With a shunting of blood from the right side of the heart directly to the left side a decrease in saturation of arterial blood occurs, the degree depending on the amount of blood returned to the left side unoxygenated. This is the explanation for the development of a compensatory polycythemia and a considerable increase in the hemoglobin content of the blood as well as an increase in blood volume. It is evident from the data presented in table 2 that the pulmonary lesion produced a great compensatory change in the quality and the quantity of the blood. Before operation polycythemia (7,200,000 cells) was present, with a corresponding increase in red cell mass (hematocrit reading 82 per cent) and hemoglobin (23 Gm. per hundred cubic centimeters). The blood volume was approximately two times the normal amount, the increase being entirely in the red cell mass. After the removal of the left lung, all of the blood was diverted to the right side and was aerated as it passed through the right lung. Immediately the red cell count fell more than 2,000,000 within two days and has remained at a high normal level. This rapid fall was the result of a dilution of the blood caused by the replacement of the blood lost during operation with plasma. The hemoglobin content was reduced from a preoperative level of 23.0 Gm. to the present level of 15.7 Gm. per hundred cubic centimeters. The hematocrit reading was likewise reduced from 82 to 54 per cent. The estimated total blood volume fell from 12,750 cc. (preoperative) to 6,900 cc. by the second postoperative day, this reduction being entirely in the erythrocytes. Ten days later the blood

12. Smith, H. L., and Horton, B. T.: Arteriovenous Fistula of Lung Associated with Polycythemia Vera: Report of a Case in Which the Diagnosis Was Made Clinically, *Ann. Heart J.* 18:589, 1939.

Dr. Paul Schaffer made studies on the blood volume of this patient.

Most of the clinical features observed in our patient have been present in the 4 previously reported patients having this condition. In view of the uniformity of the clinical picture a diagnosis can readily be made when the lesion is suspected.

After removal of the left lung the status of the blood approached the normal one, and the patient returned to work.

In the case of cavernous hemangioma (arteriovenous fistula) of the lung reported, there were associated compensatory polycythemia, polycythemia and hyperhemoglobinemia. Only 4 other cases of this combination of conditions have been found in the literature. This patient sought medical treatment for repeated epistaxis and extreme cyanosis of the hands and face. On examination he also presented distinct clubbing of the fingers and toes and evidence of pulmonary osteoarthropathy. A roentgenogram of the chest revealed a large, irregularly shaped, circumscribed opacity in the left lung and a small one in the right lung. The arterial blood had an oxygen capacity of 35.54 volumes per cent but contained only 25.10 volumes per cent. Thus only 71 per cent of the hemoglobin was oxygenated.

#### SUMMARY

Although only 4 similar cases have been previously reported, the condition in others has likely gone undiagnosed and been treated as polycythemia vera. In 2 of the 4 reported cases the patient was treated for this condition for some time before the correct diagnosis was established. When clubbing of the fingers and the toes is present, some pulmonary lesion should be suspected and a roentgen examination of the lungs made. A correct diagnosis may be readily established on the basis of altered values of blood oxygen and the finding of an opacity in the lung on roentgen examination.

volume was 6,350 cc., a value which is approximately normal; a later determination gave slightly lower value.



ment that is united to the lower pole of the left kidney, in which the fused organs lie to one side of the median line and are the result of fusion of dissimilar poles.

Abeshouse<sup>2</sup> states that congenital anomalies of the kidney are susceptible to the same pathologic complications as is the normally developed kidney. Complete urologic examination is of inestimable value in diagnosis and treatment of renal anomalies. The possibility of a renal anomaly must be borne in mind by the urologist and the surgeon in cases in which there is an obscure abdominal, pelvic or retroperitoneal mass and in those in which there are ill defined symptoms of renal origin.

The treatment of pathologic complications in cases of anomalous kidney depends not only on the type of anomaly but on the character of the symptoms and the extent of renal damage and functional impairment. Patients who do not have symptoms and who do not present any renal pathologic condition do not require any treatment. Such patients should be informed of the anomaly and advised to return for reexamination at frequent intervals.

The successful surgical treatment of an anomalous kidney demands an orderly plan of operation: proper surgical approach, that is, an operation carried out extraperitoneally through a lumbar or a lateral abdominal incision; careful attention to the vascular supply; accurate hemostasis of parenchymal incisions; proper disposition of the ureter; adequate drainage of the kidney and the renal fossa, and accurate closure of the operative wound. The operative results which were obtained in 56 cases of renal anomaly reported by Abeshouse were uniformly good; there were no deaths.

Zide and Maher<sup>3</sup> report 2 cases of crossed renal ectopia, a condition in which one kidney is displaced to the side opposite its normal position and lies below the kidney of that side, to which it may or may not be fused. Its ureter crosses the midline and then passes down to enter the bladder normally. When fusion occurs, the resulting renal mass presents a peculiar, bizarre outline, variously described as a sigmoid or a tandem kidney. The blood supply for these kidneys is usually posterior and arises from the

2. Abeshouse, B. S.: Surgery of the Congenital Anomalous Kidney, Surg., Gynec. & Obst. 78:288-303 (March) 1944.
3. Zide, H. A., and Maher, E. J.: Crossed Renal Ectopia: Report of Two Additional Cases, J. Urol. 50:560-563 (Nov.) 1943.

nearest arterial source. The branching and the course of the arteries do not follow any set pattern. Usually the venous return accompanies the arterial supply. Fixation of the ectopic kidney is due to surrounding adhesions, as well as to aberrant blood vessels. The psoas kidney, on the contrary, is supplied by vessels which have higher derivation and a downward course to the kidney. The pelvis, which is usually extrarenal is located on the ventral, or anterior, aspect of the organ. The patient's symptoms depend on the function and the location of the ectopic kidney and the complications which have occurred. One of the patients was a man, aged 28 years who had urgency and frequency of urination. The urine contained a moderate amount of pus. Cystoscopy with roentgenograms taken after the catheters had been passed showed that the right ureteral catheter followed a normal course to the region of the right kidney, while the left ureteral catheter passed from the left side of the pelvis across the sacrum to the right side of the midportion of the fourth lumbar vertebra. Pyelography showed a normal right renal pelvis and calices, while the left kidney failed to fill except for the calices in the upper part of the pelvis, which contained a small amount of opaque medium. The second patient with crossed renal ectopia was a youth aged 19 who had abdominal pain which was aggravated by strenuous activities and intravenous urograms revealed that the left kidney was normal in size, location and function but that the right kidney was located in the left side of the pelvis superimposed on the fifth lumbar vertebra and the first sacral segment. Cystoscopy revealed normal mucosa of the bladder and normal ureteral orifices. Retrograde pyelograms showed a normal left kidney and ureter. The right ureteral catheter coursed from the right side of the bladder across to the left side of the bony pelvis, where the calices and the renal pelvis of the right kidney were poorly filled but appeared normal grossly.

*Tumor.*—Moore<sup>4</sup> presents a case of mixed tumor of the kidney in an adult. A review of the literature reveals that 26 cases of this disease among adults have been reported. The growth is malignant, and cures are unusual. The patient, a man aged 56, was admitted to the hospital in 1939. In 1914 he had had an injury of his right loin. Two years later he had had several attacks of hematuria and renal colic on the right side. For the last ten years before admission to the hospital he had a swelling in the right side of

4. Moore, T.: A Mixed Tumor of the Kidney in an Adult, Brit. J. Surg. 30:381-384 (April) 1943.

number of patients were in the third year of life. The lesion affected the right kidney in 23 instances and the left in 21. Bilateral tumors, commonly reported in the literature, were not observed in the present series.

"Lump in the abdomen" and "swelling of the abdomen" were the chief complaints listed in the records of 34 patients. Hematuria was the cardinal symptom in 5 cases and apparently was considered of secondary importance in an additional 9. Pain was the presenting symptom in 3 cases but was present as a minor symptom in 5 other cases. Fever was noted in approximately half of the cases, and loss of weight and cachexia were observed in about a third. Symptoms were, in general, progressive, with an average duration of only four and a half months. In 39 cases physical examination revealed a mass or masses, variously described as being solid or cystic, firm, regular or irregular, not tender and generally unaffected by respiratory movements. In 20 instances the mass practically filled the abdomen. The presence of an abdominal mass was the most important single diagnostic sign of Wilms's tumor, although localization of the origin could not often be made on palpation alone. Ascites was noted in several cases, and in 2 there were signs of venous obstruction to the lower extremities. Evidence of emaciation was present in 15 cases, and in 15 the temperature varied from 99 to 104 F. Definitely elevated blood pressures were recorded in 4 cases.

Wilms's tumor was treated surgically in all of the 44 cases. Nephrectomy was performed in 42 cases, and exploratory operation with biopsy was carried out in 2. In 20 cases a transperitoneal approach was utilized and in 24 the posterolumbar route. In 34 cases the patients were treated by roentgen rays postoperatively, and in 21 of the more recent cases the patients received the benefit of such treatment as a preoperative measure. In this group of 21 cases good clinical results were observed in nearly all instances, as evidenced by marked reduction of the size of the neoplasms. Sometimes, indeed, it was this very shrinking process which decided whether or not operation should be done. Usually operation was performed when it was felt that maximal response to irradiation had been effected. This waiting period varied from two to six weeks, with a tendency toward earlier operation among the more recent cases in the series.

At the time of this study 37 of the 44 patients were dead. Of these, 1 died in the hospital after operation. Thirty of the remaining 36 died from the effects of the tumor within twelve months. The 2 patients who had been subjected to exploratory operation and biopsy succumbed two

months, which became much larger before path. In 1923 an examination had revealed a diagnosis of hypernephroma was made. Examination (in 1939) showed a large filling the right side of the abdomen. No cal treatment was carried out; the patient became sicker and died. At necropsy a renal tumor was found occupying the entire side of the abdomen. Histologic examination showed that it was a mixed tumor. The point of interest in this case is the length the tumor was definitely known to have present—sixteen years.

Wilms, Dockerty and Priestley<sup>5</sup> review from 1923 to 1943, and end results the 35 cases of renal sarcoma. They conclude:

renal sarcoma is a rare tumor characterized by rapid growth and early and widespread metastasis. Clinical action from other types of renal malignant lesions is generally possible. The treatment of choice is early removal of the affected kidney along with the "captured" tumor and a generous amount of perinephric fat. Roentgen therapy may be administered after operation in an effort to improve the end results which, on average, will yield but 10 per cent of 5 year survival. Pathologically, sarcomas arise from the connective tissue of the renal cortex and medulla, from capsular peripelvic smooth muscle tissue and from irregular fibroepithelial elements found in the renal capsule. The tumors can be classified satisfactorily according to these three tissues of origin.

Wilms, Dockerty and Priestley<sup>5</sup> report a comparative study of 44 cases of Wilms's tumor of the kidney. The records of 101 patients were seen at the Mayo Clinic from 1904 to 1943 inclusive and whose condition was diagnosed as Wilms's tumor, embryonal sarcoma, or tumor of the kidney or sarcoma of the kidney were reviewed carefully from the standpoint of clinical data, treatment and end results. Histologic material was available from 85 cases and was studied in gross detail, with special reference to color, size and degree of encapsulation as well as to the relation of the tumor to the individual renal substance.

Wilms's tumor occurs once among approximately 25,000 patients coming to the clinic. Twenty-nine of the 44 patients were female, and 15 were male. The ages of the patients ranged from 7 months to 59 years; the largest

5. Weisel, W.; Dockerty, M. B., and Priestley, J. T.: Wilms' Tumor of the Kidney: A Clinicopathologic Study of Forty-Four Proved Cases, *J. Urol.* 399-413 (Oct.) 1943.
6. Weisel, W.; Dockerty, M. B., and Priestley, J. T.: Wilms' Tumor of the Kidney: A Clinicopathologic Study of Forty-Four Proved Cases, *J. Urol.* 399-413 (Oct.) 1943.



and nine months respectively after operation. Five patients survived for one to two years, and 1 patient died four years after operation.

The tumors were all unilateral. The size varied from 30 by 15 by 12 cm. to 4 by 3 by 2.5 cm.; all but 2 of the specimens were larger than the normal kidney. Nearly all of the specimens demonstrated degrees of encapsulation; 33 were more or less nodular or lobulated, the remainder being globoid or unicentric.

Weisel, Dockerty and Priestley state that from a review of the literature and an analysis of their material it appears that Wilms's tumor of the kidney, although rare, is one of the most common tumors of childhood and that it is a tumor of infancy and adolescence, because 37 of their 44 patients were less than 12 years of age.

The tumors were insidious in their onset and relentless in their course. A large abdominal mass of relatively short duration was a symptom in no less than 39 of their 44 cases.

The pathologic change induced by roentgen therapy was among the most interesting features in the study. Widespread necrosis of tumor cells was almost always evident in cases in which roentgen therapy was used. The necrosis reflected the clinical observation of reduction of the size of the neoplasm. It was observed, however, that viable nests of highly malignant cells persisted in these regions of radionecrosis. From the pathologic standpoint, therefore, it would seem unwise to allow a protracted period to elapse between the date of the last roentgen treatment and the time of operation.

In the earlier days nephrectomy alone was employed most frequently. Later, nephrectomy followed by postoperative roentgen therapy was used rather widely. During recent years the immediate effectiveness of roentgen rays in diminishing the size of these tumors has become widely appreciated, and as a result this form of treatment has been employed prior to operation as well as after nephrectomy. Some have gone so far as to employ roentgen therapy alone in the treatment of Wilms's tumor. In general, treatment has been discouraging, and any possibility of improving the ultimate results in the management of this condition would be most welcome.

At present five main forms of treatment are employed: (1) roentgen irradiation alone, (2) operation alone, (3) roentgen irradiation followed by operation, (4) operation followed by roentgen irradiation and (5) irradiation followed by operation and subsequent further irradiation. All writers agree that treatment with roentgen rays exerts a remarkable effect on the size of a Wilms tumor within a few weeks after its ad-

There appears to be little support for treatment of Wilms's tumor by nephrectomy alone. Inasmuch as treatment with roentgen rays exerts such a pronounced effect on lesions of this type, there seems to be no good reason why it should not be utilized at some time in the management of these growths. If it is not employed preoperatively, it may be used postoperatively. The preferable form of treatment of Wilms's tumor is immediate nephrectomy, if the tumor is small enough to be removed without undue hazard. If risk, followed by postoperative irradiation. If the tumor is larger, a brief course of preliminary irradiation extending over two to three weeks followed by nephrectomy and subsequent further irradiation seems desirable.

*Resection.*—Mlathe<sup>7</sup> states that resection of the kidney is of inestimable life-saving value and should be used more extensively than at present. It is conceded that half of one kidney will sustain life. Indications for partial resection apply to localized benign pathologic processes in which it is anatomically possible to resect a portion of the kidney without destroying the blood supply to the remainder of the organ. Contraindications are tuberculosis, malignant lesions and war injuries which are not available for immediate treatment. Meticulous technique, including preliminary ligation of nutrient blood vessels, approximation of flaps of parenchyma with atraumatic needles and nephropexy assure success. The mortality rate is about 5 per cent, and the morbidity rate is insignificant. Function is reduced in approximate proportion to the amount of secreting renal tissue resected. Data on 13 cases of which Mlathe had first hand knowledge are reported.

McKim, Smith and Rush<sup>8</sup> were unable to find any recorded instance in which both nephrectomy and heminephrectomy had been performed on a human being successfully. They report a case in which a woman has lived twelve years with half of one kidney. During this period

7. Mlathe, C. P.: Partial Resection of the Kidney. Report of Thirteen Cases, *J. Urol.* 50:525-542 (Nov.) 1943.  
8. McKim, G. F., Smith, P. G., and Rush, T. W.: Twelve Year Survival with One-Half of One Kidney. *J. Urol.* 50:769-774 (Dec.) 1943.



Multiple simple cysts may be confused easily on surgical exploration with polycystic disease. Multilocular cysts differ from the ordinary type of multiple simple cyst in that a single large cyst is subdivided into smaller segments. Peripelvic (pyelogenic) cysts differ from simple renal cysts in causation, clinical course and treatment. Cystic hypernephroma occasionally is observed and may be confused with simple cyst, both on clinical examination and on casual surgical examination. The infrequent occurrence of hypertension caused by simple cysts is in contrast to the frequent incidence of hypertension in cases of polycystic disease.

Aspiration of cysts as a diagnostic procedure occasionally may be indicated in cases in which surgical exploration is not advisable. The procedure, however, may be unsatisfactory because of possible error of diagnosis and complications which may follow it. Surgical exploration usually is more satisfactory, and surgical excision of the cyst is a better treatment.

McCrea<sup>10</sup> states that the most frequent site of origin of a solitary renal cyst is the lower pole of the kidney. Next in frequency is the upper pole and lastly the body of the kidney. The condition may be observed at any time but is not commonly seen in the first two decades of life. It occurs most often between the ages of 30 and 50 years. The most logical treatment is resection of the cyst. However, nephrectomy may be advisable because of extensive destruction of the kidney or because of uncontrollable hemorrhage after resection of the cyst.

*Perinephric Abscess.*—Swan<sup>11</sup> presents data on 26 proved and 6 possible cases of perinephric abscess in infants and children. To classify lesions on an etiologic basis as metastatic, complicated by underlying renal disease or secondary to trauma to the kidney is important for prognostic and therapeutic reasons. If the patient is a child, a history which includes urinary symptoms or a finding of albumin or white blood cells in the urine strongly suggests a complicated type of lesion and indicates a thorough study of the urinary tract. Intravenous pyelography should be done preoperatively on all patients suspected of having perinephric abscess, unless they are too ill to tolerate the procedure. Treatment varies with the type of abscess. With the metastatic variety, as soon as the diagnosis is reasonably established incision and drainage is reasonable.

10. McCrea, L. E.: Solitary Cyst of the Kidney: Report of Two Cases, *Am. J. Surg.* **60**:328-334 (June) 1943.

11. Swan, H.: Perinephric Abscess in Infants and Children: A Study of Twenty-Six Patients Surgically Treated, *Am. J. Surg.* **61**:3-10 (July) 1943.

has led a normal life and with the exception of pregnancy, a cholecystectomy and recently menopausal cycle has been perfectly well. The patient, a woman aged 38 years, was first noted in 1930, at which time retrograde pyelographic studies showed extensive calculus pyelitis on the left side, with a stone impacted in upper end of the left ureter; on the right there were massive calculus pyelonephrosis of the entire of the double kidney and a moderate degree of extrarenal hydronephrosis of the lower ureter, which was not infected and was free of stones. Nephrolithotomy on the left kidney was performed, and a nephrostomy tube was left in place. The patient made an uneventful recovery. Four weeks after drainage of the left kidney, heminephrectomy on the right kidney was done. Seven months later pyelotomy on the right kidney was performed, and two months after this nephrectomy of the left kidney was done. Ten months after the stone, which was acting as a foreign body and preventing the healing of the sinus, was removed from the left ureter. Four years after original admission to the hospital it was noted that the patient's right kidney was functioning normally. Tests of renal function in 1933 showed a concentration of urea of 28 mg. per hundred cubic centimeters of blood, and with exception of hypertension the patient was in good general condition.

*Cysts.*—Brasch and Hendrick<sup>9</sup> state that renal cysts become of clinical significance only when they become so large or so numerous as to cause renal dysfunction or when they become apparent on physical or urographic examination. Large simple cysts frequently are observed on urographic examination. Their existence usually can be inferred by means of urography, although direct diagnosis may be uncertain. Urography, whether excretory or retrograde, offers the simplest form of diagnosis. The excretory urogram usually offers sufficient data in many cases but not in all. Greater accuracy usually is obtained by the retrograde urogram. Absence of deformity in the pelvic outline and unsatisfactory urograms are common causes of diagnostic failure. The differentiation of urographic deformity used by renal cyst from that caused by renal opacification may be exceedingly difficult, and failure to distinguish between the two deformities is a frequent cause of diagnostic error. In most cases surgical exploration will be advisable in order to establish an accurate diagnosis.

9. Brasch, W. F., and Hendrick, J. A.: Renal Cysts, Simple and Otherwise, *J. Urol.* **51**:1-10 (Jan.) 1944.

Her father had been examined, there was general anaesthesia, and a Case of Spontaneous Rupture of a Tuberculous Bladder, Brit. J. Surg. **31**:98 (July) 1944.

A woman aged 27 years had frequency of micturition for two years. On examination, pain in the lower part of the abdomen and tenderness

After many years, complained of a tuberculous bladder. The patient was so much improved, he deferred surgical treatment temporarily. Rupture—Moroney<sup>30</sup> reports a case of spontaneous rupture of a tuberculous bladder. The patient was so much improved, he deferred surgical treatment temporarily.

The patient was forced to hold his finger against the skin during the procedure. A cystogram was performed using a solution being used. The typical hourglass deformity of skidpad showed the patient had taken pus. Since the patient had free of pus, decided.

was encountered. In the examination of fifteen of the openings to the sinuses, none of which was more than 1 cm. in size and contour. Pus was normal in size and contour. Pus from these sinuses by the digital examination showed that the sinuses were normal in size and contour. Pus from these sinuses by the digital examination showed that the sinuses were normal in size and contour. Pus from these sinuses by the digital examination showed that the sinuses were normal in size and contour.

The lower portion of the bladder, so that it was seen until the verumontanum was reached with the posterior urethra, so that the narrowings were seen until the posterior urethra.

was 10 cm. long and 3 cm. wide. It was prominent posteriorly than anteriorly. The bladder compartment was between the two compartments was about 3 cm. in diameter. Search showed that they were two halves of a whole who have bonate and citric acid.

were both much smoother than the surface of the intravenous tarrate, and frequently papillomatous choice.

When the cystoscope was introduced into the bladder, it was divided into two equal parts, which were about equal in length, inflamed. However, the inflamed part was usually at the orifice. The inflamed part was usually at the orifice. The inflamed part was usually at the orifice.

and Carlson was  
me of frequency of urination,  
times daily, with occasional  
and nocturia (ten to fif-  
teens). The cysto-  
scopic examination did not  
show any abnormality.

...was a man aged 40 years, who reported a long history of urinary bladder transurethraly. In I case a perineal incision, and in another case, the bladder was excised, and the ureters and the bilateral renal pelvises were removed. At necropsy, the tubercle was confirmed.

[illegible]

ARCHIVES OF SURGERY

In addition, acidification of the urine was accomplished in 1 case in which suprapubic cystostomy had been performed for carcinoma of the prostate. Complete bacteriologic studies were carried out in 9 of the 21 cases. Although sterilization of the urine was not achieved in any of these 9 cases, it was found that treatment resulted in marked reduction of the number of organisms in 5 cases.

#### PROSTATE GLAND

Cancer.—Nesbit and Cummings<sup>33</sup> conducted a second follow-up study on a series of patients treated by orchiectomy for prostatic cancer. The study gave continued evidence of the value of this form of treatment.

Forty-five per cent of the patients remained free from symptoms twenty-one to thirty-six months after orchiectomy, but 21 patients previously reported as showing favorable response have had recurrent symptoms of advanced disease, and several of these have died. The increasing incidence of delayed failure in this series suggests that eventually all patients may fall into this category.

It is evident that endocrine therapy increases the life expectancy of patients who have prostatic cancer by causing a suppression of carcinogenic activity for temporary but varying periods and that this temporary control is accompanied clinically by a period of relief from symptoms resulting from the malignant disease. Maximal benefit to the patient may be derived by delaying endocrine treatment until it is indicated by the onset of symptoms arising from advanced or metastatic lesions. Only in this manner can the longest period of palliative relief be assured. Huggins<sup>34</sup> emphasizes that the results of orchiectomy in the treatment of prostatic cancer are not uniformly successful and that they fall into three groups: In one group, the patients (less than 5 per cent) received no or slight benefit from endocrine treatment; in the other groups, which were larger and contained a nearly equal number of patients, an improvement pronounced but unsustained (less than eighteen months) and a pronounced and more prolonged regression of the disease were obtained respectively. The improvement is greater than the palliation, which implies technically that the patient is merely made more comfortable in the

Certain benefits usually follow orchiectomy. Among the earliest changes are increased appetite and relief of pain. These effects are observed within several days after castration. They result in a gain of weight and an improvement of the anemia. Frequently there is a recession of the primary tumor, so that the hard, nodular, craggy prostate gland becomes smooth and soft and decreases greatly in size. Changes often are observed in the metastatic growths in the bones on roentgenographic examination, the metastatic lesions usually undergoing increased calcification within several months after orchiectomy. This increased density is often followed by stabilization of growth or by disappearance of the metastatic growths to roentgenographic examination.

In the entire series of 45 men on whom orchiectomy was performed, there have been 8 deaths.

35. Huggins, C.: A Summary of Endocrine Effects in Advanced Prostatic Cancer, New York State J. Med. 43:519-521 (March 15) 1943.

34. Huggins, C.: Orchiectomy in the Treatment of Prostatic Cancer, J. A. M. A. 124:122 (Jan. 8) 1944.

33. Nesbit, R. M., and Cummings, R. H.: Prostatic Carcinoma Treated by Orchiectomy: A Secondary Report Based on Seventy-Five Cases Observed for at Least Twenty-One Months Following Operation, J. A. M. A. 124:80-81 (Jan. 8) 1944.

of the

of the

and causing a demonstrable regression of the malignant neoplasm.

The regressive histologic changes observed in diethylstilbestrol-treated carcinomas of the prostate gland, as compared with the untreated specimen changes in untreated large vesicular nuclei, prominent nucleoli and granular, reticular cytoplasm. 2. In the first stage of regression there is a decrease of the size of the nuclear chromatin. Nucleoli are no longer visible, and mitoses are absent. Cytoplasmic vacuoles appear at the bases of the nuclei. 3. In the second stage of regression the nuclei are pyknotic. The cytoplasm is practically clear, and the cell membranes have ruptured, with resulting coalescence of vacuoles. With the rupture of all the cell membranes, the pyknotic nuclei and the fragments of the acinar spaces are clustered in the centers of the acinar spaces. 4. In the next stage of regression clear acinar spaces contain only remnants of pyknotic nuclei. 5. In the final stage, as Kahle and his associates have observed it so far, only stroma, consisting of smooth muscle and fibrous tissue, remains. Accumulations of brown pigment are present in some parts of the stroma.

Kretschmer<sup>37</sup> believes that not enough time

has elapsed since the procedure of orchectomy

was instituted to talk about cures in cases of

carcinoma of the prostate. The conclusions are

hasty, since most statistical studies on the cura-

bility of cancer are based on five and ten year

cures. He states that his results have not been

as satisfactory as one would be inclined to be-

lieve they should be, judging from the literature.

He reports his experience with 11 cases. Three

of the patients were dead five, eight and eleven

months respectively after orchectomy; 1 patient had

months after orchectomy, another seven

and a half months after and 1 four months after.

Some of the patients experienced a feeling of well-

being immediately after orchectomy. For

2 of the patients who died the feeling of well-

this form of treatment it should be remembered

that for cancer in other parts of the body statis-

tion of time has in itself a carcinogenic effect.

Furthermore, in many species the administra-

tion of estrogen to men for an extended length

of time has in itself a carcinogenic effect.

Kahle, Schenken and Burns<sup>36</sup> discuss 7 cases

of adenocarcinoma of the prostate gland (diag-

nosis in six proved by biopsy) in which treat-

ment with diethylstilbestrol or diethylstilbestrol

could be followed are brought up to date in this

February 1942, and the data on 5 cases which

in all 5 cases, serial histologic examination

showed definite regression of metastatic

genologic lesions, as demonstrated by serial roent-

genologic examination, in the single case in

of metastatic lesions to the lymph nodes in an-

other instance.

Massive doses of diethylstilbestrol and of di-

ethylstilbestrol dipropionate were used without

ill effects except for transient gynecomastia in a

single instance. In 1 case in which there was

an apparent recurrence of the carcinomatous

process a second course of treatment was as

effective as the first in controlling symptoms

36. Kahle, P. J.; Schenken, J. R., and Burns, E. L.: Clinical and Pathologic Effects of Diethylstilbestrol and Diethylstilbestrol Dipropionate on Carcinoma of the Prostate Gland, J. Urol. 50:711-732 (Dec.) 1943.

37. Kretschmer, H. L.: Orchectomy in the Treat-

ment of Cancer of the Prostate Gland, J. A. M. A. 123:755-757 (Nov. 20) 1943.

Prostatic hypertrophy is associated with development of masses of lymphoid tissue, an appearance frequently mistaken for an inflammatory infiltration of lymphocytes. Nodules composed only of smooth muscle are not distinctive but represent a variant in which the stromal hyperplasia does not include glands.

There is no histologic basis for the hypothesis that selective arteriosclerosis in the outer group of glands is the cause of prostatic hypertrophy. Inflammation may occur in the prostate gland in association with benign hypertrophy but is not the cause of the disease.

Degenerative changes in the epithelium and the stroma are not of special significance. The uninvolved part of the prostate gland in cases of benign hypertrophy shows atrophy and atypical hyperplasia, the histologic evidence of irregular or abnormal stimulation. Metaplasia of the epithelium of the prostate gland frequently occurs, but the histologic evidence alone is insufficient to postulate powerful estrogenic stimulation as the cause.

Carcinoma in a nodule which has undergone benign hypertrophy without involvement of the surrounding tissue is rare. When a carcinoma is present in both the tissues that have undergone benign hypertrophy and the neighboring prostatic tissue, no conclusions in regard to its origin are possible. Lateral derived from surgical operation is valueless in this connection, since only part of the prostate gland is available for study.

Recurrence of prostatic hypertrophy may be due to growth of nodules not removed at the first operation or to development of new nodules. After suprapubic prostatectomy, the compressed posterior and lateral lobes expand by stromal growth to surround the large prostatic urethra.

The enlarged prostate gland of old dogs is not comparable anatomically to the benign hypertrophic prostate gland of man.

Melick<sup>40</sup> reports that in 4 cases in which a one stage suprapubic prostatectomy was done and in 19 cases in which a two stage operation was done a shorter period of healing of the incision was obtained when nylon stay sutures were used than when catgut was used. This definite secretory activity. The stroma differs from that of the adult prostate state resembles that of the adult prostate but differs from it in the relative absence of muscle and absence of elastic tissue.

3. Kirshbaum, J. D.; Larkin, H. S., and Culver, H.: Report of a Sarcoma of the Prostate Gland: Report of a Case. *J. Urol.* 50:597-607 (Nov.) 1943.

4. Moore, R. A.: Benign Hypertrophy of the Prostate: A Morphological Study. *J. Urol.* 50:680-710 (Dec.) 1943.

40. Melick, W. F.: The Use of Nonabsorbable Stay Sutures as the Primary Means of Closure in Suprapubic Prostatectomy. *J. Urol.* 50:449-457 (Oct.) 1943.

tical results are based on five or ten year studies of so-called cures.

*Sarcoma*.—Kirshbaum, Larkin and Culver<sup>3</sup> report a case of reticulum cell (retiothel) lymphosarcoma in a man aged 25 years. The patient lived for three years with roentgen treatment. tumor metastasized locally and to distant parts. Obstruction to the ureteral orifices produced clinically the terminal picture of uremia. It was associated moderate hypertension. On 15 cases of lymphosarcoma have been cited from the literature, including those on case presented here.

*Hypertrophy*.—Moore<sup>4</sup> presents a morphological study of benign hypertrophy of the prostate gland, which, he states, occurs with increasing frequency after 40 years of age, but the in which there are clinical symptoms of early obstruction reach a maximal incidence 5 years of age. This would indicate that etiologic agent is most active during pre-termed more frequently than might be expected in the distribution of the general population. yellow race apparently is less affected with benign hypertrophy than the white or the black. Members of the white race do not show variation of incidence in different parts of world.

he sexual drive of patients who have benign hypertrophy is probably not altered significantly. first demonstrable lesion in prostatic hypertrophy is hyperplasia of the periductal, periglandular and peritubular stroma. In rare instances hyperplasia of epithelium is primary. nodules associated with prostatic hypertrophy derived most commonly from the stroma and glands of the part of the prostate gland frequently designated as the inner group of glands. s includes the peritubular glands and the anterior and medial to the ducts of the prostatic lobes. The true middle lobe of the prostate gland is involved less frequently, the anterior lobe rarely and the posterior lobe very rarely, if at all.

the typical epithelial cell of the hypertrophic state resembles that of the adult prostate but differs from it in the relative absence of definite secretory activity. The stroma differs from the normal in a relative richness of muscle and absence of elastic tissue.

3. Kirshbaum, J. D.; Larkin, H. S., and Culver, H.: Report of a Sarcoma of the Prostate Gland: Report of a Case. *J. Urol.* 50:597-607 (Nov.) 1943.

4. Moore, R. A.: Benign Hypertrophy of the Prostate: A Morphological Study. *J. Urol.* 50:680-710 (Dec.) 1943.

enumerated. The total period of hospitalization, especially for the patients on whom one stage prostatectomies were performed, approaches that for perineal and transurethral prostatectomy; thus one of the chief objections to the supra-

pubic route has been overcome. Orr, Kundert and Pyle<sup>41</sup> review the late results that follow *Transurethral Resection*. Questionnaires sent to 483 private patients. Of these 483, 407 were traced. One hundred and fifteen were found to have died from within a few months after leaving the hospital. Data obtained on 76 were insufficient for tabulation of the results of their surgical treatment. According to the patients' own statements, 160 of the total 252 were satisfied with the results of their surgical treatment. Nineteen stated that they were definitely relieved of their symptoms, not been entirely relieved of their symptoms, and intelligible replies were received from 252, and of this number 209 presented themselves for examination.

For the 483 patients treated, a total of 576 prostatectomies were found necessary for one cause or another before relief was obtained. Multiple operations were planned for 31, but because of the unusual size of the gland the number was increased to 39. The remaining 452 patients had only one resection for what was believed at the time to afford satisfactory relief of the obstruction. A second operation, because of insufficient removal or regrowth of tissue, was found necessary for 44 patients, who returned to the hospital after their original operation. Of these 44, 1 patient returned six different times for removal of recurrent growth over tissue over six years. Two patients were readmitted four times for removal of regrowth of prostatectomy. Six patients had undergone supra-

pubic and 6 perineal prostatectomy. Thirty-one had had transurethral resection performed previously. The smallest amount of tissue removed to afford relief from obstruction was 1 Gm., and the largest amount removed from any 1 patient was 117 Gm. The average weight of prostatectomy tissue removed from the first 250 patients was 12.4 Gm., and from the last 233 patients was 15.6 Gm. Twenty-seven patients underwent removal of vesical calculi by litholapaxy or cystotomy, either at the time of the resection or during their initial stay in the hospital. The average number of years of survival after operation of one or two sections of malignant prostatectomy was 3.34.

On examination of one or two sections of tissue, malignant prostatectomy was diagnosed in 45 cases, and in 6 more the condition was diagnosed as malignant on examination of additional tissue—a total of 51 cases in which malignant prostatectomy was diagnosed at the time of operation. Of the patients at the time of operation, 16 were living at the time of the report and 24 were dead.

Gutierrez<sup>42</sup> points out, on the basis of 3 consecutive cases of failure of transurethral prostatectomy in which operation had been performed elsewhere, that this form of operation is not suited to all cases of prostatic hypertrophy and that it has its limitations as well as its indications. In all 3 cases the hypertrophic tissue had been of considerable size (50 Gm., 80 Gm. and 210 Gm.); the operations had been previously performed in four years and three years previously and had been followed through all the intervening years by persistent symptoms, for which the patients had been receiving endless treatment without relief. These cases serve to prove the obvious failure here of this type of operative treatment, which has been held out as a panacea for all forms of prostatic obstruction. In all these 3 cases the patients were cured by simple perineal prostatectomy, with completely satisfactory results.

Even though transurethral resection sometimes can be repeated safely in two, three, four, five or even more stages, obviously it cannot be recommended if the patient has an enormous prostate gland, weighing more than 200 Gm. At the time of prostatectomy in 1 case reported by Gutierrez the "tunnel" that had been drilled earlier through a prostate gland had as a result presented a striking picture. In view of the fact

that the smallest amount of tissue removed to afford relief from obstruction was 1 Gm., and the largest amount removed from any 1 patient was 117 Gm. The average weight of prostatectomy tissue removed from the first 250 patients was 12.4 Gm., and from the last 233 patients was 15.6 Gm. Twenty-seven patients underwent removal of vesical calculi by litholapaxy or cystotomy, either at the time of the resection or during their initial stay in the hospital. The average number of years of survival after operation of one or two sections of malignant prostatectomy was 3.34.

41. Orr, L. M.; Kundert, P. R., and Pyle, F. J.: Late Results Following Transurethral Prostatectomy. *New York State J. Med.* 43:521-524 (March 15) 1943.

42. Gutierrez, R.: Failures of Transurethral Prostatectomy. *Letter Club*, Oct. 12, 1943, pp. 74-75.

that patients can be offered a permanent cure by an open operation in the form of conservative total prostatectomy, the folly of undertaking to remove extremely large prostate glands through the urethra becomes doubly clear. Gutierrez concludes that the coming generation of urologists should be trained on a surgical basis to use all of the three methods available for relieving prostatic obstruction: transurethral, suprapubic and perineal prostatectomy, including total enucleation of the adenoma, and subtotal and radical perineal prostatectomy for the removal of cancer of the prostate gland.

Creedy<sup>43</sup> states that loss of blood constitutes one of the principal hazards of transurethral prostatectomy. When excessive, it prolongs the operation, reduces its accuracy and increases the risk of complications and of death. The preliminary injection into the prostate gland of a mixture of isotonic solution of sodium chloride, pitressin and epinephrine hydrochloride in a series of 32 cases of transurethral resection of 30 Gm. or more of prostatic tissue has apparently reduced the loss of blood by 35 per cent and has been without harmful effects. Care must be exercised lest the patient be returned to his room before the vasoconstricting effect of the drugs has worn off.

Millner<sup>44</sup> states that in his hands transurethral resection is the operation of choice. Good results depend on the ability to recognize prostatic tissue when it is encountered and to resect down to the surgical capsule. Postoperative symptoms of cystitis are almost invariably due to leaving tissue to which the blood supply has been destroyed. In all cases of postoperative incontinence cystoscopy should be performed and any tissue impinging within the external sphincter should be removed. No patient capable of living through his preoperative preparation presents too great a risk for resection to be performed.

On the basis of study of a series of 140 cases Kretschmer and Ockuly<sup>45</sup> discuss loss of blood during transurethral resection. No attempt was made to separate carcinoma from benign hypertrophy or large vascular lateral lobes from middle lobes, bars or commissures.

In the first series of 35 cases the loss of blood per resection averaged 281.8 cc. This was constant.

43. Creedy, C. D.: The Intraprostatic Injection of Pitressin and Adrenalin in the Control of Bleeding During Transurethral Resection: A Preliminary Report. *J. Urol.* 50:593-596 (Nov.) 1943.

44. Millner, W. A.: Transurethral Prostatectomy. *New York State J. Med.* 43:517-519 (March 15) 1943.

45. Kretschmer, H. L., and Ockuly, E. F.: Determination of Blood Loss During Transurethral Resection. *J. Urol.* 51:69-71 (Jan.) 1944.

46. Young, H. H.: Calculi of the Prostate Associated with Ochronosis and Alkaptonuria. *J. Urol.* 51:48-58 (Jan.) 1944.

Ochronosis is characterized by urine of a deep brown color which becomes black on standing. If homogentisic acid is found in the urine, are described.

Four other cases from the literature in which the prostate gland was the condition discovered clinically. However, no operation was done. I case of ochronosis associated with calculi in only a study of the literature shows that in only case in which an operation has been done.

*Calculi.*—Young<sup>46</sup> reports a case of ochronosis and alkaptonuria in a man in whose urine homogentisic acid was found. Stones were discovered in the prostate gland by roentgenologic examination and removed by perineal prostatectomy, with excellent result. This is the only case in which an operation has been done.

A study of the literature shows that in only one case of ochronosis associated with calculi in the prostate gland was the condition discovered clinically. However, no operation was done. Four other cases from the literature in which the prostate gland was the condition discovered clinically. However, no operation was done.

The morbidity and the mortality rate from transurethral resection of the prostate gland are influenced definitely by the loss of blood at the time of resection.

The morbidity and the mortality rate from cases in which a hemostatic bag had been used, variably they found that it occurred in those incontinence for a few days after resection, influencing their records of patients who have slight chills and fever is slightly greater than in cases in which a hemostatic bag is not used. After checking their records of patients who have slight chills and fever is slightly greater than in cases in which a hemostatic bag is used the incidence of postoperative static bag is used the incidence of postoperative believe that in cases in which an indwelling hemostatic catheter is not as free through the hemostatic catheter as it is through the straight catheter. This delayed drainage in the presence of bleeding aids in the formation of clots which require irrigation and removal by hand, thereby affording opportunity for contamination and subsequent infection. Kretschmer and Ockuly believe that in cases in which an indwelling hemostatic bag is used the incidence of postoperative chills and fever is slightly greater than in cases in which a hemostatic bag is not used. After checking their records of patients who have slight incontinence for a few days after resection, invariably they found that it occurred in those cases in which a hemostatic bag had been used.

The morbidity and the mortality rate from transurethral resection of the prostate gland are influenced definitely by the loss of blood at the time of resection.

it was thought that stones occurred only rarely in cases of prostatic carcinoma. Cristol and Emmett's study was based on 4,136 cases of prostatic hyperplasia and 686 cases of carcinoma of the prostate gland. Prostatic calculi were present in 7 per cent of the cases of hyperplasia and in 6.3 per cent of the cases of carcinoma.

**Infection.**—Henline<sup>49</sup> states that chronic prostatitis is not a predisposing factor from a distant focus of infection or from some of the prostate gland occurs more frequently than in by far the greatest percentage of cases. Infectious infections are of common occurrence and attract attention to the prostate gland as the source of the infection. In many instances chronic prostatitis does not present any local or urinary symptoms and attention is not attracted to the prostate gland. A careful prostatic examination is required to determine which causes symptoms elsewhere in the body.

The diagnosis of chronic prostatitis is made by rectal palpation and the finding of pus in the expressed prostatic secretion by microscopic examination. The origin of the infection should be sought for carefully and eliminated. Prostatic massage with general hygiene, together, usually will eradicate a sulfonamide compound, although prolonged treatment may be required.

Complications in the urinary tract are common and should also be treated to obtain the best results from local frequent are urethral stricture, infection that routine examination of this gland should be undertaken as frequently as that of the teeth and the tonsils.

**Anesthesia.**—Harbord<sup>50</sup> reports 94 cases in which spinal anesthesia was used for removal of the prostate gland. Twelve other patients died on the operating table, although 2 patients died on the day of operation. There were no deaths on at intervals of two to twenty-six days after operation.

49. Henline, R. B.: Prostatitis and Seminal Vesiculitis: Acute and Chronic. J. A. M. A. 123:608-615 (Nov. 6) 1943.

50. Harbord, R. P.: Spinal Analgesia for Prostaticomy: A Review of Ninety-Four Cases with Novocain Dissolved in the Spinal Fluid. Brit. J. Surg. 30:235-237 (Jan.) 1943.

47. Huggins, C., and Bear, R. S.: The Course of the Prostatic Ducts and the Anatomy, Chemical and X-Ray Diffraction Analysis of Prostatic Hyperplasia and Carcinoma of the Prostate Gland. J. A. M. A. 123:646 (March 4) 1944.

48. Cristol, D. S., and Emmett, J. L.: The Incidence and Coincident Prostatic Calculi, Prostatic Hyperplasia and Carcinoma of the Prostate Gland. J. A. M. A. 123:646 (March 4) 1944.

49. Henline, R. B.: Prostatitis and Seminal Vesiculitis: Acute and Chronic. J. A. M. A. 123:608-615 (Nov. 6) 1943.

50. Harbord, R. P.: Spinal Analgesia for Prostaticomy: A Review of Ninety-Four Cases with Novocain Dissolved in the Spinal Fluid. Brit. J. Surg. 30:235-237 (Jan.) 1943.

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of the urethra with sounds up to 28, 29 or 30 F. as well as vesical irrigations and medical instillations for a considerable period, to secure patency and prevent strictures anywhere in its course.

*Minor Lesions.*—Ballenger, McDonald and Coleman<sup>52</sup> discuss disorders and lesions of the male urethra. They are due chiefly to inflammatory conditions, obstructions and hypertrophy or hyperesthesia and manifest themselves chiefly as abnormal discharges, urinary irritation and sexual disturbances. Inflammation and obstructions are intimately related.

Strictures of the urethra, bottle necks in this urinary passageway, are of common occurrence. They may be congenital, acquired or both. The recognition of a narrow point in the urethra is so easy and so important that even the most casual examination, unless the urethra is acutely or subacutely inflamed, should include the introduction of bulbous bougies into the anterior part of the urethra. Obstructions of fairly large caliber may be associated with and cause a chronic "gleety" discharge, which will not clear up until after the stricture has been dilated. The same may be said of low backache and of postpubic or pelvic discomfort.

Low backache of male patients responds remarkably well to urethral dilation and massage of the prostate gland. Relief of low backache and pelvic discomfort often follows prostatic massage and the introduction of sounds, even when the prostatic secretion shows few or no pus cells and strictures of the urethra are not detectable. Among the patients suffering from low backache who come to urologists, 50 per cent or more will respond to prostatic massage and the appropriate use of sounds and medical instillations. Occasionally, if the patient is a boy, instillations of 1 or 2 per cent solutions of silver nitrate into the deep portion of the urethra will be required after each treatment with the sound. If the patient is a boy, 1 or 2 per cent solution of intracaine ( $\beta$ -diethylaminoethyl-*p*-ethoxybenzoate hydrochloride) is injected into the urethra before the sounds are introduced.

*Occlusion.*—Dourmashkin<sup>53</sup> reports 5 cases of complete urethral occlusion of living newborn infants in which normal urination was established by creating a forced passage to the bladder with the aid of a whalebone filiform bougie and a small ureteral catheter. The occlusion involved the entire penile portion of the urethra in 2

on. In 6 per cent of the cases the anesthetic agent was unsatisfactory, necessitating secondary administration of gas and ether. The drug used as procaine hydrochloride in powdered form, and approximately 100 mg. was used in each case. The procaine was dissolved in the spinal fluid before administration.

#### URETHRA

*Foreign Body.*—Gutiérrez<sup>54</sup> reports a case of an unusually long foreign body in the urethra, consisting of a crystal stirrer 16 cm. in length by 1 cm. in thickness, which was impacted firmly in the whole length of the penile-membranous portion and which necessitated open operation for its removal. The offending foreign body had caused painful priapism of seven days' duration, with severe dysuria and tenesmus, accompanied by balanitis, balanoposthitis and a gross amount of pus and blood in the voided urine. When a foreign body is impacted in the anterior portion of the penile part of the urethra, external urethrotomy must be performed on the glans penis. Since, however, plastic operations on the penile portion of the urethra have notoriously resulted in fistulas, one should, before their performance, substitute a derivation of the urine by preliminary cystostomy in order to forestall infection and secure perfect healing. In the case reported by Gutiérrez, the painful priapism was relieved by surgical removal of the offending foreign body from the urethra. The operation was carried out with ease and without bleeding. Two months after operation the wound was firmly healed, the voided specimen was clear and the urethra was permeable to a metal sound at 30 F.

In some cases in which the urethra is contaminated by an infected foreign body, it is wise after the external penile urethrotomy to leave the wound wide open. Even if the wound is closed one should not institute drainage by an indwelling urethral catheter. Drainage should be obtained instead by aseptic catheterization, carried out three or four times a day. In such cases a low protein diet, reduction of intake of fluid and control of the bowels by opiates for six days are useful measures. Granulation and healing of the wound will occur, in most cases, without infection by the end of the second or third week. The scar remaining in the glans penis is insignificant when the operation is properly done and does not cause any disturbance of normal sexual function. After any type of external urethrotomy the patient should receive dilations

51. Gutiérrez, R.: Unusually Long Foreign Body Impacted in the Urethra, Causing Painful Priapism for Seven Days: Removal and Cure by External Urethrotomy, *J. Urol.* 49:865-871 (June) 1943.

52. Ballenger, E. G., McDonald, H. P., and Coleman, R. C.: Disorders and Lesions of the Male Urethra: Office Procedures, *J. A. M. A.* 123:599-603 (Nov. 6) 1943.

53. Dourmashkin, R. L.: Complete Urethral Occlusion in Living Newborn: Report of Five Cases, *J. Urol.* 50:747-755 (Dec.) 1943.

in 1 case.

In practically all of the cases, the patient is an adult, and it may also be considered congenital, and the patient is most likely to coincide with urethral instrumentation or acquisition of the stenosis in adults. In the examples of the urethral study in the

...which he had personal knowledge of. The report is based on a clinical study of only accepted benignity of the tract of the advanced obstructive uropathy of the cases may be expected to the com-

Etiologically, stricture of the external meatus is classified as congenital, 98 per cent of cases (Indwellin et al., 1977) trauma (Indwellin et al., 1977) and acquired, 2 per cent of cases (Indwellin et al., 1977).

acquired, instrumental infection, vaginorrhoea, nongonorrhoeal infection, and frequent catheter, instrumental infection, vaginorrhoea, nongonorrhoeal infection, and frequent orthrea, nongonorrhoeal infection, and frequent genital stenosis is analogous to, and frequently accompanies, congenital stricture in the urethra at the vesical neck or in the urethra. In Campbell's

with hypospadias (12 cases), also occurred in 3 cases of congenital stenosis present in 3 cases of epispadias and in 3 cases of the penis. Acquired stricture may result from the combination of sclerotic changes and infection of the penis. Acquired stricture may result from the combination of sclerotic changes and infection of the penis. Acquired stricture may result from the combination of sclerotic changes and infection of the penis.

changes due to back pressure and the more widespread transurethral employment of the prostatectomy among adults, particularly in the older age groups.

of the urinary tract

54. Campbell, M. F.: Stenosis of the External Urethra. J. Urol. 50:740-746 (Dec.) 1943.

St. Camille, J. C. rethral Meatus, J. C.

Stenosis of the External Carotid Artery

Mearns, J. C.

Stenosis of the External Urethra. Forty-nine of the patients examined because of so-called per-  
 M. F.: Urol. 50:740-746 (Dec.) 1943.

35. *Diagnosis Obtained*  
Anesthesia Obtained  
J. Urol. 50:508-513

Stenosis of the External  
because of so-called per-  
Forty-nine of  
53. Nephritis Obtained  
J. Urol. 50:508-513 (Oct.)  
1943.

of the External  
Anesthesia Obtained  
J. Urol. 50:508-513 (Oct.) 1943.

53. Maria Obina  
J. Urol. 50:508-513 (Oct.) 1943.  
Anesthesia Obtained by External  
(c.) 1943.

35. *Magister, J. Urol. 50:508-513 (Oct.) 1949.*

13

was well differentiated, and surgical treatment should be followed by complete cure. Warren and Olshausen<sup>58</sup> state that not enough is known of the normal variation of interstitial cells of the testicle to differentiate clearly pathologic states of these cells. On the negative side, there are certain helpful facts: Large collections of interstitial cells are not necessarily pathologic; multinucleated cells and cells in the tunica albuginea and epididymis do not necessarily indicate invasive growth, and cyclic changes of the number of interstitial cells from fetal life to senility tend to correspond inversely with changes in spermatogenesis. Hyperplasia of interstitial cells associated with chronic diseases, injury, castration, cryptorchidism, changes of environment, ingestion of drugs in man, exposure to roentgen rays and radium, transplantation of testicles and administration of glandular extracts (chorionic gonadotropin and estrogens) and serum in animals may be due entirely or largely to diminished spermatogenesis. Of 29 reported cases of increase in number of testicular interstitial cells in human beings, including 4 cases reported by Warren and Olshausen, 12 were classified as cases of hyperplasia, 13 as cases of local tumor, 1 as a case of local tumor accompanied by hyperplasia and 3 as cases of malignant tumor.

Hyperplasia occurs principally at or after 45 years of age in atrophic testicles and is discovered chiefly at necropsy. Local tumors occurred predominantly at or before 45 years of age in testicles larger than normal and are generally discovered during life and removed surgically. Two of the three malignant tumors reported by Warren and Olshausen occurred before the patient was 45 years of age. No definite criteria for diagnosing malignant lesions can be named, except for the presence of metastatic growths. However, if the testicle of a patient contains an increased number of interstitial cells, especially if the seminiferous tubules have been partially or completely destroyed, he should be carefully followed for more than ten years to watch for the appearance of metastatic growths if they are not present before that time. Counselier,<sup>59</sup> in discussing urinary incontinence of women, emphasizes the importance of a careful analysis of the cause of the incontinence and a complete understanding of the anatomy of the vesical neck, urethra and pelvic fascia plus

INCONTINENCE

58. Warren, S., and Olshausen, K. W.: Interstitial Cell Growths of the Testicle, *Am. J. Path.* 19:307-331 (March) 1943.  
59. Counselier, V. S.: Urinary Incontinence in Women, *Am. J. Obst. & Gynec.* 45:479-488 (March) 1943.

into each corpus cavernosum just below the symphysis pubis. This type of local anesthesia is simple to administer, lasts three to seven hours, does not distort the penis, appears to be as safe as any other form of local infiltration and lends itself to many kinds of operative procedures on the penis and the urethra in addition to circumcision. It has been used by Lagid and Culp on more than 300 patients with ratifying results and no toxicity.

TUMORS OF TESTICLE

Smith<sup>56</sup> reviews 50 cases of malignant tumor of the testicle. These include 2 cases of chorio-epithelioma and 2 cases of bilateral tumor. Approximately twice as many growths occurred in the fourth decade of life as in any other decade. Gynecomastia and positive reactions to prolan tests proved to have little prognostic value. In 7 per cent of cases in which metastatic lesions developed, these lesions were discovered within no years after orchiectomy. Of 8 patients without metastatic lesions not treated by roentgen therapy 2 have lived more than four years. Of 23 patients without metastatic lesions treated by roentgen therapy 13 were in good health four or more years after operation. Many of the poor results followed incomplete irradiation of the abdomen, as metastatic lesions developed in regions that had not been treated. The ultimate results or roentgen treatment which had been postponed until metastatic lesions had developed were not good. Of 12 patients who had metastatic lesions, 3 responded well to irradiation. One of these has lived more than four years, between two and three years. In cases in which metastatic lesions have developed, the thorax as well as the abdomen should be irradiated. The value of roentgen treatment is proved by the results obtained in this series of cases. Morehead and Thomas<sup>57</sup> report data on a case in which cavernous hemangioma of the testicle probably originated from the tunica vasculosa of that organ. To their knowledge, this is the first case of hemangioma of the testicle recorded in the literature; furthermore, neoplastic growth has not been attributed previously to the tunica vasculosa. An inflammatory element complicated the neoplastic process. Edema, round cell infiltration and thrombosis were evident in certain regions of the tumor. The tumor had entirely replaced the testicle but

56. Smith, G. G.: Tumor of the Testicle: Analysis of the Results Obtained in Fifty Patients Treated by X-Ray Therapy, *J. Urol.* 50:585-589 (Nov.) 1943.  
57. Morehead, R. P., and Thomas, W. C.: Cavernous Hemangioma of the Testicle, *J. Urol.* 51:72-74 (Jan.) 1944.

To reduce the discomfort of cystoscopy, the choice of anesthesia is naturally of importance. To carry out the procedure painlessly insures better cooperation on the part of the patient and assists in the acquisition of reliable information. It is comparatively easy to examine the interior of the bladder successfully when the patient is relaxed and free from pain. If the patient is female, a cotton applicator dipped in 10 per cent solution of cocaine and placed in the urethra for five or ten minutes before the passage of instruments has become a routine procedure. Two  $2\frac{1}{4}$  grain (0.15 Gm.) tablets of cocaine dissolved in 1 fluidounce (30 cc.) of sterile water immediately before injection into the male urethra has proved in many thousands of cases to produce the most efficient local anesthesia.

To infect a normal urinary tract it is necessary to traumatize it. Experiments have shown that its exposure to bacteria without trauma will not cause infection. The passage of instruments is a common cause of trauma. Infection should be avoided by first filling the urethra with a suitable lubricant or lubricating the instrument thoroughly and then passing it with great care and gentleness. A more frequent cause of trauma is the overdistention of the bladder, resulting in spasm. The instrument may be passed with skill, but when the bladder is filled beyond comfort trauma is produced, which in the presence of infection will be followed inevitably by fever and chills. When the examiner has discovered a pathologic process in the urinary tract, nothing but added trauma is gained by long-continued observation.

With the advent of intravenous urography, it seemed for a time that need of instrumental examinations, particularly the passage of ureteral catheters, would be curtailed greatly. This has not proved to be the case. The unsuspected pathologic condition that has been revealed by the general use of intravenous pyelography has made evident the need for supplementary information. This can be obtained only by ureteral catheterization and visual examination of the lower part of the urinary tract. Unless all possible information from all possible sources is at hand, both diagnosis and treatment are of doubtful validity.

Ballenger,<sup>62</sup> in discussing indications for visual examination of the lower part of the urinary tract, protests against the routine cystoscopic study of the prostate and the prostatic portion of the urethra of elderly men. In the majority of instances in which urinary obstruction is the chief symptom, adequate facts may be obtained without cystoscopy. By rectal palpation the size and the consistency of the prostate gland may be

ascertained easily. A roentgenogram will show whether or not stones are present, and a cystogram will demonstrate the amount of intravesical protrusion of the prostate as well as the diverticula, if present. Beyond the information gained from these studies little else is required except a general physical examination, urinalysis, tests of renal function and examination of the blood. Cystoscopy when the prostate is hypertrophied is likely to bring on acute retention of urine, even among uninfected patients. Among such patients the disturbing reactions are often more severe than those after transurethral resection of the obstructing prostate.

Bumpus<sup>63</sup> states that, because it is one of the most exact of clinical specialties, an accurate urologic diagnosis frequently can be obtained by several different methods. It does not follow, however, that more than a single method need be employed. Once a diagnosis of a tuberculous infection in a kidney is confirmed by the finding of acid-fast bacilli in the urine from it or extensive hydronephrosis is discovered by withdrawal of its contents, it is not imperative to make a pyelogram as confirmatory proof of what is already a known fact, since unnecessary examination may add not only to the cost but to the risk of investigation. Miliary tuberculosis has followed pyelography, and septicemia has followed overdistention of a renal pelvis.

McKim, Smith and Rush<sup>64</sup> review data on 152 cases of dysuria and nocturia in female patients whose urine was normal.

One of the most frequent causes of symptoms is the urethral caruncle. The examining physician must not be misled by normal external conditions. Many caruncles are located immediately behind a rigid meatus of small caliber. This "intraurethral" type is more prevalent than the external type and may be overlooked easily unless the following technic is used routinely: Insert in the meatus a small cotton swab saturated with 10 per cent solution of cocaine and allow it to remain five minutes. Then by gentle traction on the swab the intraurethral caruncle, if present, can be pulled forward to the external orifice, and its size, shape and location in the meatus can be noted. In several instances the contracted meatus necessitated dilation before the growth could be demonstrated on the inner surface of the urethral mucosa immediately behind the dilated orifice.

In an earlier reported series of 202 cases of urethral caruncle, the following observations in

63. Bumpus, H. C., Jr., in discussion on Bumpus,<sup>61</sup> p. 619.

64. McKim, G. F.; Smith, P. G., and Rush, T. W.: Dysuria and Nocturia in the Presence of Normal Urine in the Female, *J. A. M. A.* **123**:603-607 (Nov. 6) 1943.

62. Ballenger, E. G., in discussion on Bumpus,<sup>61</sup> p. 618.

the normal physiology of micturition before undertaking any surgical corrective procedure.

Incontinence may be either congenital or acquired. Congenital incontinence is caused by a congenital defect, the extreme of which is represented by exstrophy of the bladder. Partial epispadias usually is the most confusing defect because in some instances the anatomic relations appear normal but on cystoscopic examination the musculature of the dorsal portion of the urethra is found missing.

Acquired incontinence is that incident to childbirth and less commonly that incident to operations for cystocele and prolapse. The incontinence may vary from moderate to severe, depending on the degree of trauma. Not all of these patients require cystoscopic examination, but a direct query regarding leakage of urine, when a vaginal plastic procedure or a vaginal hysterectomy is contemplated, is essential. Cystoscopic examination in cases of severe incontinence will reveal whether the urethra is distorted or the internal sphincter is gaping or fixed.

Counseller reports a series of 26 cases in which he performed the Kennedy operation for incontinence. In this procedure the cervix is grasped with a tenaculum and the anterior vaginal wall is opened in the usual manner to within 1.5 cm. of the external urinary meatus. The urethra is separated from the pubic rami on each side. This separation must be kept close to the bone to avoid a plexus of veins and branches of the inferior vesical artery and must extend into the paravesical space. If this is done gently, fibrous adhesions between the urethra and the pubic rami can be palpated and separated, with restoration of freedom of motion to the urethra. This freedom of motion must be maintained for complete relief of incontinence, and it is accomplished by plicating the tissues under the urethra by three mattress sutures, which hold the urethra from the pubic rami. A second row of mattress sutures picks up the edges of a fascia-like structure on the lateral surface of the urethra, and these sutures when tied separate the urethra farther from the pubic rami. An additional mattress suture should be placed to plicate the inner portion of the urethra about the internal sphincter.

The restoration of the voluntary sphincter is now done. The damaged portion of this muscle which remained attached to the vaginal wall is removed with the redundant portion of the vaginal wall which formed the urethrocele. The remaining intact sphincter fibers are replaced by three no. 1 chromic catgut sutures. These sutures are passed through the vaginal wall close to the pubic rami, so as to be certain to catch

the muscle fibers of the constrictor urethrae; the inferior layer of fascia of the urogenital diaphragm. When these are tied the edges are placed beneath the middle and inner portions of the urethra. Kennedy uses silver wires instead of catgut. A male catheter is placed in the urethra for five to seven days or until the patient is out of bed, when she is advised to void normally.

The result in all 26 of Counseller's cases is complete restoration of continence. Some patients contracted cystitis and urethritis of varying degrees, which induced some urinary urgency and frequency.

#### HERMAPHRODITISM

Lattimer, Engle and Yeaw<sup>60</sup> report a case of true hermaphroditism in a Negro, aged 40 years, who showed hypospadias and no palpable testes. On the right side a rudimentary duct deferens, an epididymis and a juvenile testis were found in the abdomen. Structures resembling prostatic corpora amylacea were found where the prostate gland should have been. On the left side a rudimentary fused müllerian system emptied into the posterior urethra. In addition there were a small ovotestis and a remnant of fallopian tube on the right side. The ovary and the duct system were removed, and orchidopexy was performed. After a period of gonadotropin and androgenic hormone treatment, the hypospadias will be corrected.

#### UROLOGIC DIAGNOSIS

Bumpus<sup>61</sup> states, in a discussion of the indications for visual examination of the lower part of the urinary tract, that those who have personally undergone what in the surgical vernacular is termed a "cystoscopic examination" appreciate that, like the holy bonds of matrimony, it is no something to be undertaken lightly. The examiner who expects all his patients to fit a single cystoscope is to be censured. The dilation of urethras by sounds in order to make them fit cystoscopes, instead of using cystoscopes of suitable size, has caused much of the dread of this form of clinical investigation. Moreover, different cystoscopes are designed for different types of work, and the examiner who is not capable of utilizing the proper instrument handicaps himself and, by being thus handicapped, may fail to obtain the information most desired.

60. Lattimer, J. K.; Engle, E. T., and Yeaw, R. C.: True Hermaphroditism: A Case Report, with Interpretations, *J. Urol.* 50:481-496 (Oct.) 1943.

61. Bumpus, H. C., Jr.: Indications for Visual Examination of Lower Urinary Tract, *J. A. M. A.* 123:615-617 (Nov. 6) 1943.

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64. McKim, G. F.; Smith, P. G., and Rush, T. W.: Dysuria and Nocturia in the Presence of Normal Urine in the Female; *J. A. M. A.* 123:603-607 (Nov. 6) 1943.

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the urinary tract were noted: Urethral strictures were present in 8 cases; the strictures were located immediately adjacent to the caruncles, and all the patients gave histories of previous applications of cauterizing solutions. Urethritis was present in 81 cases in which there were varying degrees of easily recognizable urethral inflammation. In 54 cases of cysts of the vesical orifice cystic degeneration of the mucosa of the vesical orifice was demonstrated easily. In 111 cases the urine in the bladder showed infection, both acute and chronic. In 20 cases the bladder was contracted to a capacity of less than 6 fluid-ounces (180 cc.). In 2 cases interstitial cystitis was found and in 2 cases bilateral pyelonephritis. As a result of the frequency with which involvement of the urinary tract above the caruncle was demonstrated in this series, it was concluded not only that urethral caruncles should be regarded as an important etiologic factor in the production of vesical symptoms but that in many cases they act as true obstructions to the urinary outflow and produce the complications of urinary obstruction.

It is a fact acceptable to most urologists that the female urethra harbors numerous organisms, the so-called fossa navicularis being the chief receptacle.

In accordance with surgical principles of treating inflammatory lesions in other organs of the body, an inflamed bladder is let alone temporarily unless an emergent condition demands further investigation.

Rest in bed is advised, with at least eight to ten glasses (1.9 to 2.4 liters) of water in the twenty-four hour period and a soft diet, with no fruit juices. The patient is given twenty-eight  $7\frac{1}{2}$  grain (0.48 Gm.) tablets of sulfathiazole and instructed to take one tablet after meals and at bedtime.

Visualization of the interior of the bladder by cystoscopy was done in each of the 152 cases. Frequently a combination of two or more etiologic factors was found in the same case, such as pelvic abnormality and urethral cysts or intramural cystitis.

Moore<sup>65</sup> states that there exists a widespread tendency to underestimate the importance of symptoms referable to the bladder among women when examination of the urine gives negative results. An accurate estimate of the condition of the urethra is not at all a complicated procedure if an endoscopic view is obtained. Lesions involving the urethra may be overlooked easily with the average indirect vision cystoscope. It has been Moore's experience that chronic non-specific urethritis of women is often refractory

to treatment and in such cases palpation of the urethra with a sound in place will often reveal small shotlike infiltrations due to chronic inflammatory changes in the periurethral gland. Massaging the urethra lightly over the sound preferably after instillation of a mild antiseptic may hasten recovery. Gradual and gentle dilation of the urethra also has been of definite value and is attended by a minimum of trauma if rubber-covered Kollmann dilator is employed. Dilations given at intervals of ten days to two weeks may be carried finally to 35 or 40. Chronic interstitial cystitis, or panmural fibrosis is the most stubborn condition to eradicate all the entities mentioned in Moore's article. Patients who do not respond to hydraulic distention, treatment with silver nitrate or light electric coagulation and who have sufficiently distressing symptoms should be considered possible candidates for presacral neurectomy.

One of the common causes of vesical symptoms encountered in this series was cystic degeneration of the mucosa of the vesical orifice. This condition was noted in 70 cases. These cysts can be described as appearing in a variety of forms and may be classified as single or multiple, bullous or pedunculated.

The bullous type was encountered in 26 cases and appeared as superficial, rounded elevation beneath a thin urethral mucosa, which was more or less distorted by associated edema and congestion and resulted in the formation of folds of the mucous membrane with intervening clefts. It is interesting to note that in 16 of these cases not only was the urine free from infection but there was no residual urine. In the remaining 10 cases, varying amounts of residual urine were found. The cystoscopic findings in the 44 cases in which the pedunculated type predominated were entirely different. In several cases the cysts were located inside the vesical orifice adjacent to the trigone and in others they were found in the urethra just outside the sphincter.

Urinary symptoms varied in different cases, though frequency was recorded in all. In most cases, particularly in those in which there was no residual urine, frequency was aggravated while the patient was on her feet.

Selected patients suffering from these lesions were treated in the office, although the most satisfactory and permanent results have been obtained when the patient was hospitalized. With the patient under light anesthesia, preferably low spinal, the lesions are treated by direct application under vision with the high frequency spark, it being necessary not only to cauterize the base of the protruding cyst but to cauterize gently all of the mucosa of the vesical orifice.

65. Moore, T. D., in discussion on Bumpus,<sup>61</sup> p. 618.

## URINARY EXTRAVASATION

Finestone<sup>66</sup> reviews data on 32 cases of urinary extravasation, in 16 of which the patient died. Of 3 patients on whom operation was not performed, all died. Of 11 patients on whom suprapubic cystotomy was performed, 7 survived. Of 9 patients on whom external urethrotomy was performed, 6 survived. Of the 9 patients on whom operation was performed without any diversion, only 3 survived. In 2 of the last 3 cases, there were only localized conditions resembling periurethral abscess. In the third case the perineum ruptured spontaneously, thereby adequately diverting the urinary stream and saving the patient's life.

In the last 7 consecutive cases in the latter part of 1938 and 1939, when the principles discussed later were emphasized, there were no deaths.

Operative intervention is essential and is always an emergency procedure. Spinal anesthesia gives the lowest mortality rate. Besides multiple incisions of infiltrated tissues, diversion of the urinary stream is of paramount importance. Diversion of the urinary stream is accomplished by one of three methods: suprapubic cystotomy, external urethrotomy or indwelling urethral catheter (which is condemned). Multiple incisions should be short and superficial. There is no necessity for exposing the testes; unnecessary mutilation is thereby avoided. The general condition requires strenuous measures: continuous intravenous infusions, transfusions and administration of tetanus and anaerobic antitoxin, gas gangrene antiserum and sulfonamide compounds.

## URINARY ANTISEPSIS

Helmholz,<sup>67</sup> in discussing the effects of various urinary antiseptics on strains of *Escherichia coli*, states that resistance to sulfathiazole is manifested by a small percentage of strains of *E. coli*. The size of the inoculum of bacteria may determine the presence or absence of bactericidal action. Strains resistant to sulfathiazole were also resistant to urinary acidity and mandelic acid but were more susceptible to methenamine and methenamine mandelate than nonresistant strains. Sulfathiazole and sulfadiazine seem to be more effective against *E. coli* than sulf-

acetimide, sulfapyridine or sulfanilamide. In concentrations of 0.5 mg. per hundred cubic centimeters sulfathiazole is more effective than sulfadiazine.

## ORTHOSTATIC ALBUMINURIA

Prince<sup>68</sup> reports the case histories of 5 young men who had been rejected from military duty because of albuminuria. Four of these patients were proved to have orthostatic albuminuria and have since been accepted by medical examining boards for active duty with the armed forces. The fifth patient was found not to have orthostatic albuminuria and is included in this series as an excellent example of the careful studies which are necessary before this diagnosis should be made.

The various studies and examinations which were performed to determine the correct diagnosis in these cases are reported carefully and are described in such a manner that they may be repeated easily by any physician interested in similar cases of albuminuria among apparently healthy young persons.

The criteria which should be met before a diagnosis of orthostatic albuminuria is made are given and are discussed in some detail. The various "lordotic" tests are described fully, and the importance of intravenous urograms in these cases is emphasized.

Orthostatic albuminuria is a rather common condition, which is quite harmless and which usually disappears shortly after puberty and practically always by the end of the third decade of life. It does not have any effect on general health or longevity. The diagnosis of orthostatic albuminuria requires careful and thorough examinations of various types. The condition must not be confused with chronic glomerulonephritis in a latent stage.

Albuminuria of this type does not require any treatment, and curtailment of activity in this condition is contraindicated. There is no reason why young persons who have orthostatic albuminuria should not be allowed to serve with the armed forces.

## SULFONAMIDE DRUG THERAPY

Sobin, Aronberg and Rolnick<sup>69</sup> state that intrarenal foreign material following sulfonamide drug therapy is of two types: (1) precipitated sulfonamide compounds and their acetylated

66. Finestone, E. O.: Urinary Extravasation (Periurethral Phlegmon): A New Concept of the Pathogenesis and the Treatment, New York State J. Med. 43:1320-1324 (July 15) 1943.

67. Helmholz, H. F.: Effects of Various Urinary Antiseptics on Strains of *Escherichia coli*: I. Sulfathiazole; II. Urinary Acidity, Mandelic Acid, Methenamine and Methenamine Mandelate; III. Relative Value of Sulfathiazole, Sulfadiazine, Sulfapyridine, Sulfacetimide and Sulfanilamide, Am. J. Dis. Child. 65:399-411 (March) 1943.

68. Prince, C. L.: Orthostatic Albuminuria, J. Urol. 50:608-620 (Nov.) 1943.

69. Sobin, S. S.; Aronberg, L. M., and Rolnick, H. C.: The Nature of the Renal Lesion with the Sulfonamides and Its Prevention with Urea, Am. J. Path. 19:211-223 (March) 1943.



products; (2) cellular debris, with deposition of calcium and iron around or on this material. Urea simultaneously administered with sodium acetylsulfapyridine will prevent the precipitation of sulfonamide compounds and the formation of renal calculi in rats. The action of urea is independent of a diuretic effect and depends on a specific solvent effect on acetylsulfapyridine. The nephrotoxic properties of acetylsulfapyridine are mechanical and result from precipitation of the drug in the renal tract. Calcification in the kidney and resultant formation of calculus in animals treated with sulfonamide drugs are dependent on local damage to tissue and secondary deposition of calcium and iron on focal, nonviable structures.

La Towsky<sup>70</sup> presents the results of treatment with sulfadiazine on 100 patients with nonspecific infection of the urinary tract. Most of the patients received from 2 to 4 Gm. of sulfadiazine per day for four to sixty days. In general, infection of the urinary tract of patients who had benign prostatic hypertrophy, cystitis secondary to stricture, prostatitis, nonurinary operation, calculous and noncalculous pyelonephritis and epididymitis showed a satisfactory response. Patients who had infections of the urinary tract associated with adenocarcinoma of the prostate, vesical tumor and vesical diverticulum did not respond satisfactorily. All species of pathogens of the urinary tract encountered in this series of patients responded in greater or lesser degree to administration of sulfadiazine. The results of treatment of nonspecific infections of the urinary tract with sulfadiazine in this series compare favorably with the reports of the action of sulfathiazole on such infections found in the literature.

Campbell and Fobes<sup>71</sup> report a case of sulfadiazine anuria in which, the establishment of urinary drainage by ureteral catheterization having failed, for technical reasons, the life of the moribund patient was saved by unilateral ureteropyelostomy. The restoration of isolateral renal function was immediate. When anuria occurs during treatment with a sulfonamide compound and conservative noninstrumental and instrumental treatment is fruitless within forty-eight hours, surgical drainage of at least one kidney should be instituted without delay. This offers the remaining hope for saving the patient's life, for, with the return to unilateral renal func-

tion, uremia disappears and at a suitable subsequent time—preferably within seven to ten days—cystoscopic efforts to unblock the opposite upper urinary channels can be made. If the unilateral operation fails to promote free urinary drainage within twelve to twenty-four hours, or should promptly and surgically drain the opposite kidney.

Mathé<sup>72</sup> states that administration of sulfadiazine is accompanied by few side reactions; yet serious renal complications including anuria and death ensue with relative frequency. The prolonged, comparatively nontoxic effect of the drug on the gastrointestinal tract is no criterion for determining the absence of renal damage. Two types of sulfadiazine anuria are encountered: mechanical, due to blockage of the upper or lower part of the urinary tract with crystalline deposits; chemical, due to acute toxic degenerative nephritis caused by calcifying necrosis. The danger signals of impending anuria are hematuria, oliguria, azotemia and renal tenderness accompanied by flatulence, nausea and vomiting.

Prophylactic treatment consists in reducing the dose of the drug to a maximum of 4 Gm. a day, maintaining the blood level below 8 mg. per hundred cubic centimeters, forcing fluids to a daily urine output of 1,200 to 1,500 cc. and alkalizing the urine to a sustained  $p_H$  of 7.5. In the presence of anuria administration of the drug should be discontinued and ureteral catheterization and pelvic lavage, or in some cases nephrostomy drainage, should be performed. No apparent permanent renal damage has been observed among patients relieved of sulfadiazine anuria.

Mathé reports a case of mechanical sulfadiazine anuria, which occurred seven days after administration of 15 Gm. of sulfadiazine for acute bronchitis to a patient presenting bilateral ureteral stricture. The anuria was relieved by ureteral catheterization and pelvic lavage.

#### ADRENAL TUMORS

O'Crowley and Martland<sup>73</sup> state that adrenal heterotopia with adrenal glands (complete heterotopia) or a considerable portion of them (partial heterotopia) beneath the capsule of the kidneys and with no adrenal glands in their normal position is not as uncommon as the literature indicates. O'Crowley and Martland

70. La Towsky, L. W.: The Clinical Use of Sulfadiazine in Nonspecific Urinary Tract Infections—A Study of One Hundred Cases, *J. Urol.* 50:625-631 (Nov.) 1943.

71. Campbell, M. F., and Fobes, J. H.: Sulfadiazine Anuria: Its Relief by Ureteropyelostomy, *Am. J. Surg.* 61:99-102 (July) 1943.

72. Mathé, C. P.: Sulfadiazine Anuria Due to Mechanical Blockage of the Ureters by Crystalline Deposits: Report of a Case, *Urol. & Cutan. Rev.* 47:168-171 (March) 1943.

73. O'Crowley, C. R., and Martland, H. S.: Adrenal Heterotopia, Rests, and the So-Called Grawitz Tumor, *J. Urol.* 50:756-768 (Dec.) 1943.

have encountered this condition eight times in the routine examination of 5,000 consecutive bodies.

The explanation of this anomaly, which in O'Crowley and Martland's experience is always bilateral, is unknown. As the renal capsule is said to be completed at a time in early fetal life when the adrenal cortex is far distant, it would seem that a mechanical displacement is impossible. It suggests that embryologic data are incomplete, that exceptions occur or that pluripotent cells exist which can form either renal parenchyma or adrenal cortex.

Contrary to some authorities, this anomaly seems not to have any effect on the life of the patient. In the experience of O'Crowley and Martland, it neither shortens life nor predisposes to infections, tuberculosis or debilitating diseases. No endocrine disturbances were observed.

The recorded high incidence of status lymphaticus with this anomaly is not borne out in this series of cases.

In cases of adrenal-renal heterotopia the surgeon in performing nephrectomy would remove

the adrenal gland unwittingly. Since the heterotopic glands are hypoplastic and in addition do not contain any medulla (or scant medulla in extracapsular portions only), such an operation might cause symptoms suggesting adrenal insufficiency.

Finally, the demonstration that the entire adrenal cortex, or large portions of it, may be found beneath the renal capsule remaining on the kidney after decapsulation and the finding in some of these cases of many small, isolated bits of cortical tissue near these subcapsular adrenals, but scattered over the surface of the kidney, greatly strengthen the opinion held by many pathologists that the so-called adrenal rests are bits of cortical adrenal tissue which have become misplaced during development.

It is reasonable to assume, therefore, that some renal hypernephromas may arise from such misplaced cortical adrenal tissue.

The only other explanation would be the concept that pluripotent cells exist which may give rise to any of these structures. There is no way of refuting such an argument.

# PROGRESS IN ORTHOPEDIC SURGERY FOR 1943

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY  
OF ORTHOPAEDIC SURGEONS

## I. CONGENITAL DEFORMITIES

PREPARED BY J. HIRAM KITE, M.D., ATLANTA, GA.

Only about one eighth of the average number of articles on congenital deformities have appeared during the past year.

Of the work that has been reported, I place that of Warkany and his associates first.<sup>1</sup> They state that it is desirable to prevent rather than to treat congenital defects. This desire has kept alive among physicians a definite interest in research concerned with the causes of malformations. Apparently a great variety of factors can interfere with the normal development of the embryo. During the last few decades the discovery of genetic factors which produce malformations has attracted a great deal of attention, while research in the field of environmental teratogenic factors, in mammals at least, has lagged. However, some important discoveries made in recent years promise to renew interest in the environmental factors. It is of special interest that in several instances a relationship has been found between a faulty maternal diet and anomalies of the offspring. Franke and Tully have described the development of malformations in chick embryos the mothers of which were fed grains containing selenium. With the recognition of the importance in nutrition of trace substances, particularly vitamins, it appeared possible that a qualitative maternal dietary deficiency could cause abnormal intra-uterine development of the embryo or fetus.

Warkany and Nelson in 1940 described the appearance of skeletal abnormalities in the offspring of rats reared on a deficient diet. They found the frequency of osseous defects in 100 cleared abnormal specimens to be as follows:

Tibia . . . . .93	Hand . . . . .54	Maxilla . . . . .8
Mandible . . .80	Sternum . . .52	Scapula . . . . .6
Ribs . . . . .75	Ulna . . . . .50	Clavicle . . . . .6
Fibula . . . .63	Humerus . .34	Femur . . . . .1
Radius . . .58	Hindfoot . .31	

In summarizing their study they say that congenital malformations induced in rats by maternal

nutritional deficiency date back to the cartilagenous or precartilagenous stage of the structure affected. The defects of ossification are secondary results, caused by faulty development of precursors of the bones. Many cartilaginous structures show a lack of division in the longitudinal and transverse direction; this leads to reduction in the number of skeletal elements to syndactylism and brachydactylism in the hand. The radius, ulna, tibia and fibula are frequently shortened in the cartilaginous stage. Ossification is delayed and faulty, and eccentric centers of ossification lead to an abnormal arrangement of the trabeculae of the bones.

Hilliard<sup>2</sup> reports a case of chondro-osseous dystrophy with punctate epiphyseal dysplasia. The infant had short upper arms with relatively large spadelike hands and flexed fingers. The humerus on both sides was short and thick, with splayed ends. The elbow joint had grossly irregular epiphyses. The radius and the ulna were normal in length, and the metacarpals were larger than normal, with an hour-glass appearance, and contained denser areas at the ends. The femurs were short and thick, the condyles presenting a balloon appearance. The patellas had a stippled appearance, due to punctate dense ossification. The tibia and fibula were normal in proportions but showed dense areas in the upper and lower ends. Above the lower end of the tibia, fibula, radius and ulna there was a zone of diminished density. He says that the work of Harris shows that this deformity is really an example of a fundamental deficiency in cartilage; the extreme condition is achondroplasia, and the least abnormal is congenital dislocation of the hip, which is probably due to a failure to maintain the hereditary integrity of the epiphysis, as a result of mucoid degeneration of the cartilage.

Resnick<sup>3</sup> reports 3 cases of hereditary chondroplastic genu varum. He says that dyschondroplasia is a retardation of the normal

1. Warkany, J.; Nelson, R. C., and Schraffenberger, E.: Congenital Malformations Induced in Rats by Maternal Nutritional Deficiency, *J. Bone & Joint Surg.* 25:261 (April) 1943.

2. Hilliard, C.: Chondro-Osseous Dystrophy with Punctate Epiphyseal Dysplasia, *Brit. J. Radiol.* 16 (May) 1943.

3. Resnick, E.: Hereditary Dyschondroplastic Genu Varum, *J. Bone & Joint Surg.* 25:202 (Jan.) 1943.

transformation of primordial cartilage into growing bone, which results in irregularity of ossification at the epiphysal-metaphysal junction of the long bones. The first case was described by Ollier in 1899. Since that time, many cases have been reported in the literature, and recently there have been several articles describing dyschondroplastic bow legs. He reports the cases of a mother, a daughter and a son with extreme bow legs.

Resnick<sup>4</sup> also reports the case of an Italian mother and identical male twins with epiphysal dysplasia punctata. All 3 showed roentgenographic evidence of multiple osteochondritis with underdevelopment of the epiphyses, not associated with a definite hypothyroid state. No symptoms were associated with the osteochondritis except those of the hip joints. At the time this report was written, the mother had deformed femoral heads and necks, which caused pain and a limp. One child, in whom epiphysal changes left a deformed head and neck of the femur, also had moderate pain on active use, while the other child, whose left upper femoral epiphysis regenerated so that normal contour resulted, was free of symptoms.

Chondrodystrophia calcificans congenita is discussed by Raap,<sup>5</sup> who reports 4 cases. This rare condition was first described by Conradi in 1914. The deformity has been reported under varied names, with a tendency toward the name chondroplasia. Raap thinks, however, that the term chondrodystrophia appears more logical and has added the two descriptive adjectives. He studied roentgenograms of a 10 month old twin with a thoracic condition and found a mottled granular appearance in the ankles, wrists and other joints, which in contour followed the bony structures with normal ossification but presented angular densifications rather than rounded densities. The other twin, who had just died of pneumonia, was exhumed and found to have changes in the joints like those of the living twin. Microscopic sections from the dead twin showed an increase of fibrous tissue of periosteal character. Directly under this periosteum a formation of cartilage was noted. The deeper cells were acquiring a cartilaginous character. The deepest layers of cells formed osteoid tissue, which was partly calcified. The parents showed normal bony structures in these areas. A baby born two weeks later showed the same deformity, and a

2½ year old sister showed the remains of this same condition. He says that these abnormal calcifications are marked at birth and disappear by the age of about 3 years. All chemical and other studies on the blood gave normal results, and there was no evidence of dwarfism, cretinism, rickets or scurvy.

Arthrogryposis multiplex congenita is a term used to designate contractures of the joints. The term "arthrogryposis" is a combination of two Greek words, meaning literally a crooked or bent joint. Katzeff<sup>6</sup> reports briefly 18 cases from the Children's Hospital in Boston. She says that the extremities lack the usual anatomic contours, having instead a stuffed-sausage-like appearance. Little muscle is palpable. The structures overlying the joints feel thickened and contracted. Dimples are frequently seen over the patellas and elbows. In most of the involved muscles passive correction of the contractures is possible to a few degrees, although some are rigid, allowing no correction. These gross abnormalities are symmetric, distinctive and readily recognizable. Histologically there are atrophy and fatty replacement of the involved muscles. The younger patients are treated by manipulations, with or without anesthesia, supports and surgical corrections. The older patients are treated by fasciotomy, capsulotomy, lengthening of tendons, open reduction of hips and arthrodesis for the correction of clubfoot. "These badly disabled children, presenting at birth a discouraging picture, were definitely improved by treatment."

[ED. NOTE (J. H. K.).—A report on this interesting subject would have been more helpful to the reader who was not familiar with arthrogryposis if the writer had made a more detailed analysis of the cases. She states that the feet were "involved," without any mention of the types of deformity present. In my experience the common deformity is an atypical clubfoot. Naming the types of treatment used fails to tell the entire story of the treatment of this condition. From this article one would get the impression that the treatment is easy and sure. Any one having extensive personal experience with arthrogryposis would say that it is one of the most discouraging congenital deformities to treat. It is important from the standpoint of treatment that an early diagnosis be made, but it is much more important that the nature of the condition be recognized and that it be explained to the parents, so that they will not expect the good results in these stiff joints which they have seen in stiff joints not associated with arthrogryposis. This explanation will save much embarrassment later.

4. Resnick, E.: Epiphysal Dysplasia Punctata in a Mother and Identical Male Twins, *J. Bone & Joint Surg.* 25:461 (April) 1943.

5. Raap, G.: Chondrodystrophia Calcificans Congenita, *Am. J. Roentgenol.* 49:77 (Jan.) 1943.

6. Katzeff, M.: Arthrogryposis Multiplex Congenita, *Arch. Surg.* 46:673 (May) 1943.

The prognosis is so bad for this condition that I have often questioned the wisdom of spending a large amount of charity funds on children with this deformity. The treatment requires a much longer time than is usually expected, and the tendency to recur is much greater. No statement is made in this report about recurrences. The strong tendency to recur is one of the outstanding features of the condition. None of my patients

held the correction obtained by the first course of treatment. They all returned for more treatment at a later date. The statement is made that open reduction of the hips was used, but the final results are not mentioned. In my cases the stiff hips which could not be moved with the patient under anesthesia were allowed to remain dislocated, since they were stable, and they do not seem to be any the worse for it.]

## II. DISEASES OF GROWING AND OF ADULT BONE

PREPARED BY JOHN A. SIEGLING, M.D., CHARLESTON, S. C.

Few of the conditions in this section have any relationship to military combat, but a review of the literature for the year reveals a number of previously unreported cases of diseases of bone in selectees.

*Growth of Bone.*—From a study of 84 children, Sontag and Lipford<sup>7</sup> conclude that acute disease does not materially affect the appearance of centers of ossification. This is at variance with the work of Francis and Todd.

Lurie, Levy and Lurie<sup>8</sup> present a method of determining the age of bone which is simpler and more practical than previous methods but which is still somewhat complicated. The method is based on graphs on which is recorded the average time of appearance and fusion of epiphyses. Since this time varies in boys and girls, two graphs are given. Four roentgenograms are then taken for each person—one of the hand, including the wrist, one of the elbow, one of the pelvis and one of the foot, including the ankle. By using the two graphs in conjunction with the chronologic age, the normal age of the bones can be determined, and by comparing the roentgenograms of the child with the norm, it can be ascertained whether or not the age of the bones is accelerated or retarded.

*Disease of Bone Due to Decompression.*—Allan,<sup>9</sup> in an interesting paper, calls attention to the essential similarity of lesions of bone in caisson disease and lesions of bone as a result of decompression in high altitude flying. He states that in an ascending airplane the pressure of nitrogen in the lungs falls and nitrogen is released in the blood in the form of bubbles, which pro-

duce emphysematous and embolic symptoms. The article calls attention to the fact that the favorite areas for lesions of bone are the long bones and the shoulder and hip joints. Articular lesions are frequent. Roentgenograms reveal well defined mottled areas of increased density involving the medullary portions of the diaphysis and producing no cortical changes. The articular lesion is represented by mottled changes of irregular ossification in the head of the femur or humerus, with flattening of its articular surface, irregularity and narrowing of the cartilage space and marginal lipping.

The author stresses the importance of recognizing the clinical and roentgenographic features of this disease, with its ultimate relationship to possible claims for compensation. It is of paramount interest in time of war, as the incidence of illness caused by decompression increases with high altitude flying.

*Aseptic Necrosis.*—The clinical and roentgen diagnosis of this osseous condition is now generally recognized. Lewis<sup>10</sup> gives a brief summary of the pathologic and roentgenographic observations in post-traumatic aseptic necrosis, stressing the importance of early diagnosis. Brailsford<sup>11</sup> emphasizes the belief that there is a period of from one to four years during which necrotic bone is plastic and during which it should be protected from stress and strain while resubstitution is occurring.

*Thyroid Gland.*—Subsequent to the publication of the report of Cavanaugh, Shelton and Sutherland in 1936, concerning the evidence of metabolic (thyroid) deficiency in 5 cases of Legg-Perthes disease, a great many persons have used thyroid in its treatment. Gill<sup>12</sup> re-

7. Sontag, L. W., and Lipford, J.: Effect of Illness and Other Factors on the Appearance Pattern of Skeletal Epiphyses, *J. Pediat.* **23**:391-409 (Oct.) 1943.

8. Lurie, L. A.; Levy, S., and Lurie, M. L.: Determination of Bone Age in Children, *J. Pediat.* **23**:131-140 (Aug.) 1943.

9. Allan, J. H.: Decompression Disease of Bone, *J. Aviation Med.* **14**:105-111 (June) 1943.

10. Lewis, R. W.: Post-Traumatic Necrosis of Bone. *Am. J. Roentgenol.* **49**:593-599 (May) 1943.

11. Brailsford, J. F.: Avascular Necrosis of Bone. *J. Bone & Joint Surg.* **25**:249-260 (April) 1943.

12. Gill, A. B.: Relationship of Legg-Perthes Disease to the Function of the Thyroid Gland, *J. Bone & Joint Surg.* **25**:892-901 (Oct.) 1943.

ports a careful study of 20 cases of Legg-Perthes disease, which controverts this previous report.

Jacobs<sup>13</sup> reports 2 cases of juvenile hyperthyroidism in which there was osteodystrophia fibrosa cystica with diffuse osteoporosis complicated by pathologic fractures. One of the patients recovered after thyroidectomy, and the other, who had not been operated on, remained toxic. The condition simulates von Recklinghausen's disease closely.

*Osteitis Deformans.*—Reports of sarcoma associated with Paget's disease continue to filter into the literature, and the frequency of the association is more than casual. In different reported series, the incidence varies from 6.1 per cent to 14 per cent. Kirshbaum<sup>14</sup> reports a case of giant cell fibrosarcoma of the skull associated with Paget's disease and states that every case of sarcoma of the skull should be investigated for the coexistence of Paget's disease. Pike<sup>15</sup> reports 3 cases of osteogenic sarcoma in patients with Paget's disease, and Campbell and Whitfield<sup>16</sup> report 3 cases of vertebral sarcoma secondary to Paget's disease. Strachstein<sup>17</sup> calls attention to the possibility of mistaking osteitis deformans for metastatic prostatic carcinoma, and the converse. Symmetric involvement is usual; clinically, however, mono-osteitic Paget's disease certainly exists. Groh<sup>18</sup> reports 9 cases with roentgenographic proof of its localized existence. It is felt, however, that the evidence in these cases is somewhat inconclusive, as it is not substantiated by pathologic study.

*Fragilitas Ossium.*—Interest continues in this obscure disease for which no treatment has yet been suggested. Bickel, Ghormley and Camp<sup>19</sup> report a study of 40 cases of this condition, which, on a basis of family history, can be classified into a hereditary and a nonhereditary, or

congenital type. Farber and Margulis<sup>20</sup> have traced a family of 52 members through four generations, 12 of whom had been affected with fragilitas ossium. The series illustrates the hereditary character of the disease, and the authors state that the most constant feature of the condition is scleral imperfection. In this series males and females were equally affected and deafness occurred in 4 cases.

Brailsford<sup>21</sup> reports 9 cases of various types of osteogenesis imperfecta.

*Parathyroid Glands, Renal Insufficiency and Bony Changes.*—Increasing emphasis is being placed on changes in bones associated with renal insufficiency. Follis and Jackson<sup>22</sup> studied sections from vertebrae of 39 persons who had died of renal insufficiency and found histologic changes in 50 per cent. Excessive osteoid was the principal abnormality rather than osteitis fibrosa.

Soffer and Cohn<sup>23</sup> carefully differentiate primary and secondary hyperparathyroidism, stressing the presence of adenoma in the primary condition and hyperplastic glands, with or without characteristic osseous changes, in secondary hyperparathyroidism. Secondary hyperparathyroidism may occur in patients with chronic renal disease, multiple myeloma, carcinomatous metastasis to bones, Cushing's syndrome, rickets and osteomalacia. The most common cause of secondary hyperparathyroidism is chronic renal disease. Curtis and Feller<sup>24</sup> report a case which illustrates that sometimes primary hyperparathyroidism resulting in renal damage and primary renal disease resulting in hyperparathyroidism may so resemble each other in their respective terminal stages as to be indistinguishable either clinically or at postmortem examination.

A great deal of interest has been evinced in the association of osteitis fibrosa cystica with tumor of the parathyroid gland if the number of case reports can be taken as an index. Orr<sup>25</sup> reports a case in which the cysts of the bones

13. Jacobs, J. E.: Osteodystrophia Fibrosa Cystica and Juvenile Hyperthyroidism, South. M. J. 36:668-673 (Oct.) 1943.

14. Kirshbaum, J. D.: Fibrosarcoma of the Skull in Paget's Disease, Arch. Path. 36:74-79 (July) 1943.

15. Pike, M. M.: Paget's Disease with Associated Osteogenic Sarcoma, Arch. Surg. 46:750-753 (May) 1943.

16. Campbell, E., and Whitfield, R. D.: Osteogenic Sarcoma of Vertebrae Secondary to Paget's Disease, New York State J. Med. 43:931-938 (May 15) 1943.

17. Strachstein, A.: Carcinoma of the Prostate: Pitfalls in Diagnosis, with Report of Two Cases, J. Urol. 19:118-124 (Jan.) 1943.

18. Groh, J. A.: Mono-Osteitic Paget's Disease as Clinical Entity, Am. J. Roentgenol. 50:230-243 (Aug.) 1943.

19. Bickel, W. H.; Ghormley, R. K., and Camp, J. D.: Osteogenesis Imperfecta, Radiology 40:145-154 (Feb.) 1943.

20. Farber, J. E., and Margulis, A. E.: Blue Scleras, Brittle Bones and Deafness, Arch. Int. Med. 71:658-665 (May) 1943.

21. Brailsford, J. F.: Osteogenesis Imperfecta, Brit. J. Radiol. 16:129-136 (May) 1943.

22. Follis, R. H., and Jackson, D. A.: Renal Osteomalacia and Osteitis Fibrosa in Adults, Bull. Johns Hopkins Hosp. 72:232-241 (April) 1943.

23. Soffer, L. J., and Cohn, C.: Primary and Secondary Hyperparathyroidism, Arch. Int. Med. 71:630-649 (May) 1943.

24. Curtis, L. E., and Feller, A. E.: Hyperparathyroidism with Calcinosis and Secondary to Renal Disease: Report of a Probable Case, Ann. Int. Med. 17:1005-1014 (Dec.) 1942.

25. Orr, I. M.: Case of Parathyroid Adenoma, Brit. J. Surg. 30:375-377 (April) 1943.

disappeared after parathyroidectomy and the blood chemistry became normal. Royde<sup>26</sup> tells of a similar case, in which death from hemiplegia prevented knowledge of the effect of the operation on the changes in the bones.

Gorham<sup>27</sup> stresses the differential diagnosis of hyperparathyroidism, with particular reference to Albright's syndrome, which is characterized by osteitis fibrosa cystica, brown pigmented spots on the skin and precocious puberty, particularly in females. The differential diagnosis is particularly important to avoid unnecessary operation on the parathyroid gland, as surgical treatment is futile in Albright's syndrome.

*Osteopetrosis and Osteopoikilosis.*—Several cases of osteopetrosis have been reported during the year, bringing the total to about 120. The case of Zimmermann<sup>28</sup> presents the usual roentgenographic findings of osteosclerosis, and clinical manifestations of blindness and deafness, due to encroachment of the sclerotic bone on the cranial foramina. A previously unreported finding is diminution in the size of the auditory meati. Rosenthal and Erf<sup>29</sup> stress the differentiation of osteopetrosis and myelofibrosis from refractory types of anemia, splenomegaly and leukemia by sternal puncture and biopsy. Linsman and McMurray<sup>30</sup> present a case of fluoride osteosclerosis, which they feel is unique; but a number of cases of fluoride osteosclerosis have been previously reported.

Two cases of osteopoikilosis are reported. In 1 case, recorded by Horwitz,<sup>31</sup> the condition was discovered by chance on roentgen examination; in the other, recorded by Thompson, Hoover and Fulton,<sup>32</sup> it was found in a selectee who complained of pain in the joints. He was rejected for military service. Phalen and

Ghormley<sup>33</sup> report a case of osteopathia condensans disseminata associated with coarctation of the aorta and discuss diminution of the blood supply as a possible cause, but they finally agree with others that all of the sclerosing osteopathies are probably due to some defect of the genetic arrangement, with faulty differentiation and growth of bone from mesenchyme.

*Meliorheostosis.*—This condition was originally described by Leri and Joanny in 1922 and has characteristically been monomelic. Of the approximately 40 cases reported in the literature, that of Carpender and co-workers<sup>34</sup> is the only one in which both lower extremities were involved.

*Calcinosis.*—Inclan<sup>35</sup> reports 3 interesting and relatively rare cases of calcareous granuloma characterized by the presence of a calcified tumor with rapid and gigantic growth, which apparently in each instance arose from a bursa and involved surrounding muscle. The lesions were cured surgically. The author failed to determine the cause but believes this condition to be entirely different from calcinosis circumscripta.

*Crushing Injury.*—Bywaters<sup>36</sup> writes a thorough article on a condition which until recently has been little known. When first described, in 1941, by Beal and Bywaters, it was thought to be a new entity, but search of the literature revealed that it was described by German authors during World War I. The Medical Research Council in England has records of 70 cases.

The typical crushing injury results when a person is pinned by a limb beneath beams or pieces of masonry for several hours. When first removed he seems well, but he soon goes into shock. Protein-containing fluids help restoration of normal blood pressure, and the patient's condition seems better until the first or second urine passed is observed to contain blood and oliguria occurs. Meanwhile the limb swells and becomes hard and tense. Blisters are seen. Patchy anesthesia and varying degrees of paralysis are present. The patient continues in a state of mental apathy for about a week. The end of the first week is a critical period, for renal failure is characteristic. Diuresis occurs, and granular casts are seen in the urine. Death

26. Royde, C. A.: Case of Osteitis Fibrosa Cystica with Parathyroid Tumor, *Brit. J. Surg.* **30**:169-175 (Oct.) 1942.

27. Gorham, L. W.: Differential Diagnosis of Hyperparathyroidism with Especial Reference to Albright's Syndrome, *New York State J. Med.* **43**:415-418 (March 1) 1943.

28. Zimmermann, C. A. W.: Osteopetrosis (Albers-Schönberg Disease) with Case Report, *Radiology* **40**:155-162 (Feb.) 1943.

29. Rosenthal, N., and Erf, L. A.: Clinical Observations on Osteopetrosis and Myelofibrosis, *Arch. Int. Med.* **71**:793-813 (June) 1943.

30. Linsman, J. F., and McMurray, C. A.: Fluoride Osteosclerosis from Drinking Water, *Radiology* **40**:474-484 (May) 1943.

31. Horwitz, M.: Osteopathia Condensans Disseminata (Osteopoikilosis), *Radiology* **40**:404-407 (April) 1943.

32. Thompson, R. H.; Hoover, R., and Fulton, H. F.: Osteopoikilosis, *Am. J. Roentgenol.* **49**:603-605 (May) 1943.

33. Phalen, G. S., and Ghormley, R. K.: Osteopathia Condensans Disseminata Associated with Coarctation of the Aorta, *J. Bone & Joint Surg.* **25**:693-700 (July) 1943.

34. Carpender, J. W. J.; Baker, D. R.; Perry, S. P., and Outland, T.: Meliorheostosis: Report of a Bilateral Case, *Am. J. Roentgenol.* **49**:398-404 (March) 1943.

35. Inclan, A.: Tumoral Calcinosis, *J. A. M. A.* **121**:490-495 (Feb. 13) 1943.

36. Bywaters, E. G. L.: Crushing Injury, *Brit. M. J.* **2**:643-646 (Nov. 28) 1942.

occurs unexpectedly. In about one third of the 70 cases there was recovery. The prognosis is more favorable for a crushed arm than for a crushed leg.

The treatment as outlined by Bywaters consists first of administering alkaline fluid in amounts up to 3 liters a day, or enough to make the urine alkaline. Shock is treated with plasma, serum or blood, and local treatment is given to wounds and fractures. If the limb is viable, the author advises elevation, fascial incisions, administration of alcohol by mouth and local application of cold to the limb and heat to the body. If the limb is nonviable, amputation should be done early to prevent absorption of autolytic substances.

With the hope of explaining the pathogenesis of renal failure in "traumatic anuria" (crush syndrome), Corcoran, Taylor and Page<sup>37</sup> applied partially occluding tourniquets to the limbs of dogs for four hours and caused marked depression of renal function. They feel that renal vasoconstriction associated with the onset of shock explains the transient signs of renal irritation which may follow injury. Although it may play a part in the genesis of the syndrome, it alone does not reproduce this state.

*Phosphatase in Diseases of Bone.*—Jaffe and Bodansky<sup>38</sup> state that there are two large groups of phosphatase—acid and alkaline. According to these authors, alkaline phosphatase activity gives a rough indication of the severity and activity of Paget's disease and of rickets. In the latter, it not only is a good indicator of the severity of the condition but gives better information relative to the abolition of the rachitic state than does the calcium or the phosphorus content of the blood. The level of phosphatase and the severity of skeletal alterations, observed in roentgenograms, seem to parallel each other in hyperparathyroidism. From investigation it appears that the factor underlying the elevation is new formation of osseous tissue.

*Muscle Hernias.*—Two articles dealing with this condition have been published. Both deal with the condition as found in soldiers. McMaster<sup>39</sup> emphasizes the similarity of the small muscle hernia to varicosities on inspection. Most of the hernias are found on the anterolateral sur-

face of the leg and are due to enlargement of a normal opening in the fascia for a nerve or blood vessel. The author reports 21 cases with 38 hernias in 1,800 admissions to an orthopedic clinic. Kitchin and Richmond<sup>40</sup> also report cases of hernia of muscle in soldiers.

*Bursitis.*—There seems to be an increased incidence of this condition with the accelerated work program. Schneider<sup>41</sup> has made an investigation of the trabeculae which are found in bursas and has revealed them to be composed of collagenous connective and adipose tissue, bone, fasciculi of skeletal muscle, arteries, veins and nerves.

Burgess<sup>42</sup> describes an interesting technic for the care of acute and chronic bursitis, in which a cataract knife is thrust into the bursa under local anesthesia and an incision then made through the bursal sac into the adjacent subcutaneous tissue. The fluid is pressed out into the soft tissues and a compression bandage applied. The author reports good results in 14 cases, with no loss of time from work. Buck, McDonald and Ghormley,<sup>43</sup> after examination of 270 specimens of bursas, obtained principally at operations for hallux valgus, conclude that adventitious bursas develop in fibrous connective tissue and are not present at birth. The process is one of mucoid and myxomatous degeneration rather than one of secretion.

*Sudeck's Atrophy.*—There has been a surprising interest in this condition, manifested by numerous reports. De Takáts and Miller<sup>44</sup> present an excellent article in which they conclude that the syndrome of Sudeck's atrophy is the result of a chronic stimulation of somatic and possibly of efferent vasodilator fibers. The reflex may soon subside, or it may become chronic and progressively increasing in its effects. Pain, localized and spreading, vasodilatation and osteoporosis characterize the fully developed syndrome, but the osteoporosis is a comparatively late manifestation. Emphasis is placed on early treatment, as progressively more radical methods are required later. The authors believe that the emotional status of the patient

40. Kitchin, I. D., and Richmond, D. A.: Multiple Muscle Herniae, Brit. M. J. 1:602-603 (May 15) 1943.

41. Schneider, C. L.: Trabeculae Traversing Human Bursae, Anat. Rec. 87:151-163 (Oct.) 1943.

42. Burgess, E.: Treatment of Traumatic Bursitis by Internal Paracentesis, Am. J. Surg. 62:165-168 (Nov.) 1943.

43. Buck, R. M.; McDonald, J. R., and Ghormley, R. K.: Adventitious Bursas, Arch. Surg. 47:344-351 (Oct.) 1943.

44. de Takáts, G., and Miller, D. S.: Post-Traumatic Dystrophy of the Extremities: A Chronic Vasodilator Mechanism, Arch. Surg. 46:469-479 (April) 1943.

37. Corcoran, A. C.; Taylor, R. D., and Page, I. H.: Immediate Effects on Renal Function of the Onset of Shock Due to Partially Occluding Limb Tourniquets, Ann. Surg. 118:871-886 (Nov.) 1943.

38. Jaffe, H. L., and Bodansky, A.: Diagnostic Significance of Serum Alkaline and Acid Phosphatase Values, in Relation to Bone Disease, Bull. New York Acad. Med. 19:831-848 (Dec.) 1943.

39. McMaster, P. E.: Muscle Hernia of the Leg, U. S. Nav. M. Bull. 41:404-409 (March) 1943.



aggravates symptoms. Treatment depends on the duration of symptoms and consists of repeated injections of procaine hydrochloride into the injured area, paravertebral sympathetic block, periarterial sympathectomy and sympathetic ganglionectomy.

*Peripheral Vascular Disease.*—Shumacker<sup>45</sup> emphasizes the beneficial effect of sympathectomy on obliterative arterial and vasospastic disease and the necessity of careful preoperative study to determine if the proposed sympathectomy will help materially. Excellent illustra-

tions and text give an exceptionally clear description of dorsal and lumbar sympathectomy.

Homans<sup>46</sup> explains traumatic vasomotor spasm and the accompanying pain mechanism on the basis of a peculiar progressive and persistent reflex disorder involving the sensory nerves of the blood vessels, the spinal cord and the sympathetic system.

Hildenbrand<sup>47</sup> discusses the beneficial effect of physical therapy in the treatment of peripheral vascular disease.

45. Shumacker, H. B.: Sympathectomy in the Treatment of Peripheral Vascular Disease, *Surgery* **13**:1-26 (Jan.) 1943.

46. Homans, J.: Vasomotor and Other Reactions Injuries and Venous Thrombosis, *Am. J. M. Sc.* **20**: 313-328 (March) 1943.

47. Hildenbrand, E. J. C.: Physical Therapy Measures in the Treatment of Peripheral Vascular Diseases, *South. M. J.* **36**:224-228 (March) 1943.

### III. INFANTILE PARALYSIS

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Approximately three hundred articles on the various problems connected with poliomyelitis are listed in the *Quarterly Cumulative Index Medicus* for 1943. The majority of these are concerned with laboratory experiments with small animals, problems in epidemiology and transmission and physical therapy, owing to the stimulation of the work of Miss Kenny. A great many articles are repetitious. I have chosen only those reports which I felt would be most appropriate and interesting. It is obvious that space could not be allotted for fair abstracting of all the fine work described in the various scientific journals for the past year.

*Causation, Transmission and Epidemiology.*—Rosenow,<sup>48</sup> of the Mayo Clinic, holds the hypothesis that the causative agent of poliomyelitis is a pleomorphic streptococcus. He has consistently isolated a specific type of streptococcus from the stools of patients having epidemic poliomyelitis. Virus virulent for mice was obtained from stools, and the virus was produced with streptococci isolated from stools of patients in the acute stage of the disease. He suggests that the growth of streptococci in the gastrointestinal tract may be an important source of specific toxic products and of the virus in epidemic poliomyelitis.

Wesselhoeft<sup>49</sup> states that it is generally accepted by the members of the medical profession

that a virus with peculiarities of its own is the etiologic agent in anterior poliomyelitis. Quoting Sabin and Armstrong, he says: "It is one of the smallest filterable viruses and is resistant to 1 per cent phenol and 15 per cent ether; furthermore, it is resistant to the usual degree of chlorination used to destroy enteric bacteria in drinking water. It is destroyed by oxidizing agents such as hydrogen peroxide and potassium permanganate, by ultraviolet rays, and by heating to 55 C. or higher for 5 minutes." The virus is transmitted from person to person; this implies that man is the reservoir of the infection. Whether cotton rats and mice can harbor the human virus is one of the most recent topics of discussion. Experimentally the human virus is pathogenic for certain monkeys, and their susceptibility has made it possible to advance knowledge of the disease. Poliomyelitis is not a natural disease of the monkey, however, and observations for determining its mode of spread are limited to man himself. Apparently the portal of entry is the mouth. The virus leaves the body in the stools. Persons who have been in contact with patients with poliomyelitis have had the virus in their stools without showing any signs of the disease. During epidemics many persons who have been exposed by contact may show slight gastrointestinal disturbances and influenza-like maladies without involvement of the central nervous system. These findings are suggestive of a much wider spread of the infection than is indicated by the actual number of cases reported. The work of Aycock and Kramer confirms this conception, for it shows that immunity to poliomyelitis increases with age,<sup>45</sup> as does immunity to other common infectious dis-

48. Rosenow, E. C.: Isolation of Specific Types of Streptococci and Virus from the Stool in Studies of Epidemic Poliomyelitis and Encephalitis and the Production of Virus from the "Poliomyelitic" Streptococci. *Proc. Staff Meet., Mayo Clin.* **18**:5-16 (Jan. 13) 1943.

49. Wesselhoeft, C.: New Conceptions of Acute Poliomyelitis. *Bull. New England M. Center* **5**:160-163 (Aug.) 1943.

cases. It is only when the central nervous system is involved that the disease can be recognized clinically.

Wyllie<sup>50</sup> presents modern views on the cause and early diagnosis and feels that the infective agent is a virus. There are several possible portals of entry. The early theory advanced by Flexner and Lewis, that the virus passes from the nasopharyngeal mucosa by way of the olfactory nerve to the olfactory centers, is receiving less support. The gastrointestinal tract as a portal of entry seems most likely. The fact that abrasions on the skin may be a possible portal of entry is based on the number of persons who acquire poliomyelitis after wading or swimming in virus-contaminated water. There is still considerable evidence that the oral pharynx is a possible site of invasion, since the average number of cases of infection following tonsillectomy is by far greater than the number of cases in which tonsillectomy is not done. Fairbrother and Hurst, according to Wyllie, feel that the virus spreads along the axons and not along the peripheral lymphatics. The axons themselves are not damaged during the passage, but damage occurs at the ganglion cell stations. The rate of transmission along the axons is estimated to be 5.8 cm. a day. The virus can travel from the brain to the spinal cord, or vice versa. He recommends three weeks of quarantine.

Aisenberg and Grubb<sup>51</sup> were able to transmit poliomyelitis to a monkey by inoculation of a cavity in the pulp of a tooth. Pathologic changes characteristic of poliomyelitis were found in the gasserian ganglion and in many of the ganglion cells. This is only a preliminary report, and this possible route of invasion should receive further study.

Howe and Bodian,<sup>52</sup> in an effort to establish the existence of a pathway by which the virus invades the central nervous system from the gastrointestinal tract, fed a chimpanzee by stomach tube material infected with the human strain of the virus. On the fourth day, during the paralytic stage, this animal was killed, and cross-sections were made through different ganglions through representative levels of entire spinal cord and through various ab-

dominal viscera. All the tissue examined was normal except the celiac ganglion and the sympathetic chain of ganglions. These tissues showed histologic evidence of invasion by the virus. This experiment suggested to them that the inflammatory process was confined to the abdominal portions of the sympathetic nervous system, and therefore it seemed a likely pathway for invasion of the central nervous system from the gastrointestinal tract. [Ed. NOTE.—These observations are not in agreement with those of Sabin,<sup>53</sup> who concludes that the visceral efferent pathway by way of collateral sympathetic ganglions, such as the celiac ganglion, is not a common route for progression of the virus from the intestine to the spinal cord. This conclusion is based on his ability to isolate the virus from the celiac plexus of only 1 of 8 patients examined, and in this 1 the paralysis was bulbar. The conclusions are further substantiated by failure to isolate the virus from the plexus of 5 orally infected monkeys.]

Jungeblut and Dalldorf,<sup>54</sup> in trying to determine the source of the virus of a small epidemic in New York, found a dead house mouse in the home of a person who had died of infantile paralysis. From this mouse they were able to isolate the virus, which produced flaccid paralysis in albino mice, cotton rats and hamsters. They also isolated from the brain stem of the dead patient a virus which was capable of inducing infantile paralysis in albino mice, cotton rats and hamsters. The two viruses were similar in that there was some neutralization with convalescent serum from patients involved in this epidemic.

Prior to 1940 Trask, Paul and Melnick<sup>55</sup> attempted to isolate poliomyelitis virus from flies, mosquitoes and other insects which were collected during eight epidemics, with negative results. In 1941, owing to improvement of methods and availability of the Java (*cynomolgus*) monkey, the workers in three laboratories (Paul; Sabin and Wood, and Toomey) reported the detection of virus in flies which were collected during the summer and fall of 1941 in areas of epidemics.

53. Sabin, A. B.: Pathology and Pathogenesis of Human Poliomyelitis, *J. A. M. A.* **120**:506-511 (Oct. 17) 1942.

54. Jungeblut, C. W., and Dalldorf, G.: Epidemiological and Experimental Observations on the Possible Significance of Rodents in a Suburban Epidemic of Poliomyelitis, *A. J. Pub. Health* **33**:169-172 (Feb.) 1943.

55. Trask, J. D.; Paul, J. R., and Melnick, J. L.: The Detection of Poliomyelitis Virus in Flies Collected During Epidemics of Poliomyelitis: I. Methods, Results, and Types of Flies Involved. *J. Exper. Med.* **77**:531-544 (June) 1943.

50. Wyllie, W. G.: Poliomyelitis—Modern Views, *Etiology and Early Diagnosis*, Practitioner **150**: 3-224 (April) 1943.

51. Aisenberg, M. S., and Grubb, T. C.: Poliomyelitis Induced by Inoculation of Tooth Pulp Cavities, *Bact.* **46**:311 (Sept.) 1943.

52. Howe, H. A., and Bodian, D.: A Note on the Infection of Poliomyelitis Virus from the Gastrointestinal Tract in the Chimpanzee, *J. Pediat.* **21**:713-6 (Dec.) 1942.

The authors' method consisted of catching flies in traps which were baited with fish and placed outdoors near the house or privy. Flies were usually collected in six hours between 10 a. m. and 4 p. m. Biting insects were caught in nets. The flies were then preserved at a low temperature until ready for use. One to 600 flies were washed in 50 cc. of distilled water, and the same fluid was used to wash the inside of the container in which the flies were kept. This suspension was used for nasal instillation, while another portion, to which ether had been added (for bactericidal purposes), was used for intra-abdominal injection. Monkeys were inoculated intranasally on each of three successive days. Also 10 to 20 cc. of the suspension was given to each of the monkeys by one intra-abdominal injection. Poliomyelitis developed in 4 of the 39 monkeys, and the virus was isolated. All positive results were obtained with Java (*cynomolgus*) monkeys. All the suspensions used contained blow flies and greenbottle flies, but house flies were present in only 2 of the 4 specimens that elicited positive reactions.

In their second paper Trask and Paul<sup>56</sup> report on the clinical circumstances under which flies were collected. These were captured within areas of epidemics during and after the epidemics. Of 8 samples collected during epidemics, 4 yielded the virus. There was a potential (though not proved) source of virus (in the form of "exposed" human feces of recent origin) within a few yards or feet of four sites where flies were collected. Flies collected from three of these sites yielded the virus. The findings to date therefore merely indicate that under certain circumstances the virus is carried by flies and possibly their feeding habits may be responsible. The presence of the virus in these particular samples of flies could be entirely a resultant and not a causal factor in human poliomyelitis.

Bang and Glaser<sup>57</sup> carried out experiments with Theiler's mouse "poliomyelitis" virus and Lansing's mouse-adapted strain of human poliomyelitis virus, which showed that the virus may be recovered from an adult fly only when the adult itself is infected by feeding. Theiler's virus was recovered from the common house fly as long as twelve days after infection, but Lansing's virus

survived only two days. These experiments were undertaken not to secure data on the transmissibility of human poliomyelitis by flies but to furnish biologic background for further study.

The fact that the virus of poliomyelitis has been found in flies caused Power, Melnick and Bishop<sup>58</sup> to make a limited survey of the population within a given locality in the city New Haven, Conn., in the summer of 1942. This was a non-epidemic year for poliomyelitis in the vicinity. This study was carried out over four months. Their conclusions were: (1) the total fly population reached its greatest size in July; (2) the common greenbottle fly was by far the dominant species of the summer; (3) the large bluebottle fly replaced the common greenbottle fly in dominance during the latter part of the summer. In no sample were they able to detect the virus of poliomyelitis.

Trask and Paul<sup>59</sup> isolated the virus from the stools of monkeys into which the virus had been introduced by intracutaneous inoculation. This was the first time that the virus had been recovered from the stools after this type of inoculation.

Maxcy,<sup>60</sup> after reviewing fifteen articles on water as a means of transmission of poliomyelitis virus, concludes that at the present time there is insufficient evidence to justify the belief that water is a medium of any practical importance in the spread of this disease and that its epidemiologic pattern differs from that of diseases known to be water borne.

Wenner and Casey<sup>61</sup> during an epidemic of poliomyelitis in Alabama in the fall of 1942, made a study to determine the extent to which the population at large were carriers of the poliomyelitis virus during the epidemic. Stools from 176 of 181 persons were tested to determine the carrier rate in the adult and the juvenile population. The virus was found in the stools of only 3 children 2 to 6 years of age. None was found in adult stools. Though evidence of poliomyelitis was widespread in the population, only persons who were ill during the epidemic provided infective stools. The ease of detection of the virus diminished with decline of the epidemic. They

58. Power, M. E.; Melnick, J. L., and Bishop, M. B.: A Study of the 1942 Fly Population of New Haven. *Yale J. Biol. & Med.* **15**:693-705 (May) 1943.

59. Trask, J. D., and Paul, J. R.: Intracutaneous Inoculation of Poliomyelitis Virus in Monkeys and Its Detection in Their Stools, *Ann. Int. Med.* **17**:975-978 (Dec.) 1942.

60. Maxcy, K. F.: Hypothetical Relationship of Water Supplies to Poliomyelitis, *Am. J. Pub. Health* **33**:41-45 (Jan.) 1943.

61. Wenner, H. A., and Casey, A. E.: A Community Study of Carriers in Epidemic Poliomyelitis, *J. Clin. Investigation* **22**:117-125 (Jan.) 1943.

56. Trask, J. D., and Paul, J. R.: The Detection of Poliomyelitis Virus in Flies Collected During Epidemics of Poliomyelitis: II. Clinical Circumstances Under Which Flies Were Collected, *J. Exper. Med.* **77**:545-556 (June) 1943.

57. Bang, F. B., and Glaser, R. W.: The Persistence of Poliomyelitis Virus in Flies, *Am. J. Hyg.* **37**:320-324 (May) 1943.

concluded, therefore, that the virus does not remain active in the stools of most persons for more than a few weeks.

With the knowledge that neutralizing antibodies against poliomyelitis virus are not always found in the serum of patients immediately after they recover from the acute stage of the disease, Toomey<sup>62</sup> carried out some interesting experiments with horse serum which had been immunized with the virus of poliomyelitis. One experiment was carried out to determine whether horses which had been immunized could be kept immunized to a point where their blood serum would continue to show the same high titer of neutralizing antibodies. Twelve sets of neutralization tests were done. A titer of 1:250 was maintained for two years providing the horses were repeatedly inoculated with the "fortified" virus. Another experiment was carried out to determine whether the combination of virus and early specimens of serum, obtained a few weeks after the completion of immunization, would accelerate the production of poliomyelitis when injected intracerebrally into monkeys and whether if neutralizing antibodies were not found immediately after immunization they could be found at some subsequent date. Two horses were inoculated with a 10 per cent suspension of "fortified" antigen over several months. The first 9 specimens of serum obtained from 1 horse when given in combination with the virus accelerated the production of poliomyelitis in monkeys inoculated intracerebrally. Identical results were obtained with the first 3 specimens from the other horse. The antibodies were slow in developing and did not appear in the blood of the first horse until about one year after the beginning of immunization. The highest titer of antibodies, a titer of 1:250, was reached approximately fifteen months after the beginning of immunization and was still present twenty months after the beginning of immunization. He also found that the titer for the first horse dropped from 1:250 to 1:150 approximately two years after the beginning of immunization. By repeated injections of "fortified" antigen the animals in which the titer of antibodies had dropped from 1:250 to a lower titer could be reimmunized to a point where potent neutralizing antibodies could again be found in the blood serum. [Ed. NOTE.—Further studies of this nature should be carried out, the results of which might shed some light on the now confused status of the use of human convalescent serum in the treatment of early poliomyelitis.]

62. Toomey, J. A.: Delayed Production of Poliomyelitis Antibodies, *Am. J. Dis. Child.* 66:121-125 (Aug.) 1943.

*Pathology.*—Peers,<sup>63</sup> in studying lesions of the central nervous system during the convalescent period of poliomyelitis in man, shows the widespread invasion to which the central nervous system is subjected. A study was carried out on 3 patients, 1 of whom survived seven weeks, 1 fifteen weeks and 1 eighteen and a half weeks. The first 2 died of intercurrent infections. The cause of death of the third was not given, but it was not due to poliomyelitis.

From 2 of the patients the brain and the entire spinal cord, with most of the thoracic and lumbar root ganglions, the sympathetic chain and the gasserian and celiac ganglions, were removed. Microscopic examination showed that lesions in the cerebral cortex, consisting of perivascular collars of lymphoid cells and interstitial foci of microglia and astrocytes, were confined to the paracentral lobules. Some diminution in the number of Betz cells also appeared probable. Only minimal lesions were found in the basal ganglions and the thalami. In the midbrain the substantia nigra presented the most severe damage. Lesions in the pons were confined to the tegmentum. Loss of nerve cells was extensive in Deiters' nucleus and more patchy and asymmetric in the motor nuclei of the fifth and seventh nerves.

In the cerebellum lesions were found only in the tectal nuclei and in the cortex of the vermis. The most marked changes in the medulla consisted of cellular loss and scarring in the reticular substance similar to those seen in the pons. The spinal cord presented an almost complete loss of nerve cells throughout the entire length of the anterior horns of gray substance. In contrast, the lateral horns were comparatively spared. Patchy and asymmetric lesions were found in Clark's column. No changes appeared in the posterior horns.

In the white matter of the spinal cord there was a mild diffuse demyelination of most of the ventral and lateral columns with the exception of the pyramidal tracts.

A few small foci of lymphoid cells were found in the gasserian, dorsal root and sympathetic ganglions. Similar lesions were found in the meninges, but no lesions were found in the choroid plexus.

Dublin and Larson<sup>64</sup> made postmortem examinations in 12 cases of poliomyelitis, which revealed constant lymphoid hyperplasia of intestinal

63. Peers, J. H.: The Pathology of Convalescent Poliomyelitis in Man, *Am. J. Path.* 19:673-695 (July) 1943.

64. Dublin, W. B., and Larson, C. P.: Pathological Findings in Poliomyelitis, *Am. J. Clin. Path.* 13:15-17 (Jan.) 1943.

mucosa and mesenteric nodes. No lesions were found in the sensory ganglions or in the peripheral nerves, but the posterior horns of gray matter of the cord were involved. This involvement suggested to him an explanation of the painful stimuli which occur in poliomyelitis. In 1 case a second attack, which proved fatal, occurred four and a half months after the initial attack. Postmortem examination in this case revealed old (astrocytic gliosis) and new (lymphocytic and polymorphonuclear proliferations) cellular changes as evidence of infection with both attacks.

Carey<sup>65</sup> made a study of motor end plates and muscle fibers in monkeys inoculated with the Armstrong-Lansing strain of virus. Microscopic examination showed the disappearance of many motor end plates, which resulted in denervation at the myoneural junction, and the appearance of masses of inclusion bodies near the degenerated motor end plates. He also noted that the degeneration which began in the motor end plates proceeded in a centripetal direction in the axis-cylinders of many motor nerves. The rate of this degeneration was often unequal in the same muscle fiber.

Sabin<sup>53</sup> feels that recovery of a neuron only partially damaged by direct invasion of the virus accounts for the transitory paralysis in some cases. He states that the inflammatory reaction is the result rather than the cause of the neuronal damage. He made an excellent study of the pathologic features of poliomyelitis. He showed that although the primary lesion is in the anterior horn cells there is almost always some involvement of the posterior horns and the dorsal root ganglions of the spinal cord. He also demonstrated neuronal damage in the vestibular nuclei of the medulla, the roof nuclei and the vermis of the cerebellum and the motor cortex. The area of Brodmann of the precentral gyrus is described as "the center from which the impulses initiating voluntary movements on the opposite side of the body descend to the motor nuclei of the cerebrospinal nerves." The fibers of this area and fibers connecting this area with other subcortical regions are concerned with the correlation of postural and volitional motor control. [ED. NOTE.—Sabin shows that this area is a frequent site of damage to the central nervous system. May not these features in part account for the incoordination and mental alienation about which one has heard so much recently?]

65. Carey, E. J.: Morphologic Effects of Poliomyelitis Virus upon Motor End Plates in the Monkey. *Proc. Soc. Exper. Biol. & Med.* **53**:3-5 (May) 1943.

*Second Attacks of Poliomyelitis.*—Nelson and Green<sup>66</sup> report that the Harvard Infantile Paralysis Commission found in a total of 6,000 cases 4 cases in which true second attacks of poliomyelitis had occurred. In all 4 cases the patients were under observation before, up to and subsequent to the time of the second attack. The histories and the clinical data of the 4 cases are cited. All diagnoses were established on the basis of the nature and the distribution of the paralysis. The attacks occurred under circumstances epidemiologically consistent with infantile paralysis. Segmental involvement of the spinal cord in each attack was different. They state that Fischer and Stillerman have made the only effort to determine the actual incidence of second attacks. Their estimation of the rate for second attacks was 3.6 per thousand new cases. This is somewhat higher than Nelson and Green's ratio, which was 0.6 per thousand. Available data suggested to them that the incidence of second attacks is approximately the same as that of recognized first attacks in the general population. This was not their definite conclusion, however. The average interval between attacks in their cases was five years, and the shortest was two years. They report that no accepted second attack reported in the literature has occurred in less than two years after the initial attack.

Dublin and Larson<sup>64</sup> report a second attack occurring four and a half months after the original attack. Postmortem examination revealed old healed lesions from the first attack and new lymphocytic and polymorphonuclear proliferation from the second and fatal attack. [ED. NOTE.—I treated a patient with infantile paralysis beginning two months after the onset. This patient showed unmistakable calcaneovarus deformity with accompanying muscular weakness in the opposite foot, which followed an acute illness eight years previously. Clinically this was a second attack of the disease.]

*Tonsillectomy and Poliomyelitis.*—In an effort to explain the etiologic relationship between tonsillectomy and poliomyelitis, McCormick<sup>67</sup> states that it has long been recognized that lymphatic hypertrophy frequently is associated with poliomyelitis. The fact that other degenerative diseases of the central nervous system, including neurosyphilis, encephalitis, spinal sclerosis, beriberi and other conditions of vitamin B deficiency,

66. Nelson, N. B., and Green, W. T.: Second Attacks of Anterior Poliomyelitis: Report of Four Cases. *Am. J. Dis. Child.* **65**:757-762 (May) 1943.

67. McCormick, W. J.: Tonsillectomy and Poliomyelitis: A New Concept of Etiological Relationship. *M. Rec.* **156**:164-167 (March) 1943.

are accompanied by a somewhat similar lymphatic reaction indicated to him that generalized lymphatic hypertrophy is a response to the degeneration of nerve cells generally rather than a specific response to poliomyelitis. He also points out the relationship of lymphatic hypertrophy to vitamin B deficiencies. The author raises the question of the possible etiologic relationship of the basic constitutional condition of the patient which is responsible for the lymphatic involvement necessitating the tonsillectomy and the effect of the anesthesia from the standpoint of nutritional deficiency and anoxia. Comparative figures on the incidence in the 1937 outbreak in Toronto are cited.

Sabin<sup>68</sup> was unable to infect tonsillectomized monkeys by painting virus over the areas of operation.

Toomey and Krill<sup>69</sup> removed the tonsils from 6 monkeys and then flooded the denuded areas with a 10 per cent suspension of virus for five days, with negative results.

Francis,<sup>70</sup> in studying the factors involved in the infection of 5 children in one family with poliomyelitis soon after tonsillectomies, concluded that tonsillectomy serves to precipitate the severe disease in children who are apparently healthy carriers. The cases of these 5 children were reported by Toomey and Krill in 1941.

*Pregnancy and Poliomyelitis.*—Harmon and Hoyne<sup>71</sup> described the clinical course of two pregnancies, which adds further strength to the evidence that pregnancy has little influence on the course of poliomyelitis in the paralyzed mother, and conversely that in utero infection of the fetus occurs rarely, if at all. In both cases the mother survived and the convalescence from poliomyelitis was uneventful. In 1 instance the infant was stillborn. They were unable to isolate the virus from the spinal cord and concluded that death was produced by anoxia, because the mother had extreme respiratory difficulty and had to be placed in the respirator to sustain life during the height of the acute illness. The second

baby was healthy, with no evidence of any paralysis at 10 months of age.

*Diagnosis.*—Rosenow<sup>72</sup> describes a cutaneous test for early diagnosis of poliomyelitis. This test is made by intradermal injection of 0.03 cc. of a 10 per cent solution of the euglobulin fraction of horse serum immunized to the streptococcus of poliomyelitis. The need for such a test is great, since specific changes in the spinal fluid are not always present for accurate diagnosis. Moreover, changes in the fluid do not occur until after penetration of the central nervous system by the infecting organism.

Rosenow<sup>73</sup> used this cutaneous test as a control for the size and number of therapeutic injections of poliomyelitis antistreptococcus serum necessary for best results. He concludes that the antigen, or toxin, is neutralized by the antistreptococcus serum and that the streptococcus is not a passive invader but a part of the infectious process in poliomyelitis now generally attributed to the virus. This human serum was first used in the treatment of the acute form of the disease in an epidemic in Davenport, Iowa, in 1917. The mortality rate in a series of 23 untreated patients was 35 per cent. In a series of 58 patients receiving the serum the mortality rate was 17.2 per cent. Seven patients of this group were practically moribund at the time of the first treatment. With these excluded, the death rate among the remaining 51 was only 5.9 per cent. There was often prompt disappearance or diminution of subjective symptoms, such as headache, pain in the affected extremity or extremities, restlessness and hyperesthesia or mental apathy; twitching or spasms of muscles, nausea and vomiting and diarrhea disappeared; reflexes that had been absent, unequal, diminished or increased became normal, or more nearly normal; lowering of the pulse rate, drop in temperature, usually after an initial short rise, and lessened rigidity of the neck or the spinal column were noted; there was no extension of progressive paralysis, and function of the muscles improved.

Jervis and Strassburger<sup>74</sup> describe a case of fatal poliomyelitis which was diagnosed clinically as infectious polyneuritis. The diagnosis of infectious polyneuritis was made on the basis of ab-

68. Sabin, A. B.: Experimental Poliomyelitis by the Tonsillopharyngeal Route with Special Reference to the Influence of Tonsillectomy on the Development of Bulbar Poliomyelitis, *J. A. M. A.* **111**:605-610 (Aug. 13) 1938.

69. Toomey, J. A., and Krill, C. E.: Tonsillectomy and Poliomyelitis, *Ohio State M. J.* **38**:653-655 (July) 1942.

70. Francis, T., Jr.: An Epidemiological Study of Poliomyelitis Following Tonsillectomy, *Tr. A. Am. Physicians* **57**:277-282, 1942.

71. Harmon, P. H., and Hoyne, A.: Poliomyelitis and Pregnancy, with Special Reference to the Failure of Fetal Infection, *J. A. M. A.* **123**:185-187 (Sept. 25) 1943.

72. Rosenow, E. C.: A Diagnostic Cutaneous Reaction in Acute Poliomyelitis, *Proc. Staff Meet., Mayo Clin.* **18**:118-128 (April 21) 1943.

73. Rosenow, E. C.: Studies on the Treatment of Epidemic and Experimental Poliomyelitis with Antistreptococcal Serum: Summary of Results, *Proc. Staff Meet., Mayo Clin.* **18**:403-408 (Oct. 20) 1943.

74. Jervis, G. A., and Strassburger, P. J.: Guillain-Barre Syndrome ("Infectious Polyneuritis") and Acute Anterior Poliomyelitis, *Am. J. Dis. Child.* **65**:431-439 (March) 1943.

normal spinal fluid, i. e., high total protein content and normal cell count, bilateral and symmetric distribution of muscular weakness, greater involvement in the proximal than in the distal portions of the extremities and the presence of optic neuritis. They stress the difficulty in differentiating between the two diseases and suggest that a large number of cases of the Guillain-Barré syndrome may be instances of poliomyelitis with a favorable outcome.

*Early Treatment.*—Toomey<sup>75</sup> inoculated 6 monkeys with Flexner's M. V. strain of poliomyelitis virus. Three were given 5 cc. of a 5 per cent solution of azosulfamide intravenously twice a day for seven days. All of the animals except 1 acquired quadriplegia at the same time. The one exception had been given azosulfamide. It became paralyzed a day earlier than the others. Sulfanilamide is the active component of azosulfamide. He thus concludes that this drug does not modify or prevent poliomyelitis in the *Macaca mulatta* monkey. [ED. NOTE.—The result of this experiment is in keeping with clinical results obtained with sulfonamide compounds in the treatment of other virus diseases.]

McCormick<sup>76</sup> compares the symptoms and the pathologic features of poliomyelitis with beriberi and other anoxic conditions and concludes that vitamin B deficiency may be a major etiologic factor in poliomyelitis. He believes that the pain and the spasm in muscles in poliomyelitis are due to anoxia of the tissues. Whereas the pain and the spasm are relieved by increasing the blood supply (by application of external heat, as recommended by Miss Kenny), the same results are obtained by a biochemical means, with vitamin B. Satisfactory results of this treatment in 4 cases are reported.

Toomey<sup>77</sup> treated a total of 9 patients with infra-red rays. Three of these patients had paralysis of the facial nerve due to poliomyelitis, and 6 had paralysis of the facial nerve due to peripheral neuritis. There was no movement in the muscles supplied by the facial nerve in the 3 patients with poliomyelitis prior to the treatment. Immediately after application of heat from infra-red rays they were able to move these muscles voluntarily for a few minutes. There was no movement in the muscles supplied by the facial nerve after application of heat from infra-red rays when paralysis

was due to peripheral neuritis. He concludes from these observations that the patients with infantile paralysis must have had some fibers left connecting the facial muscles with the nucleus of the seventh nerve, since these muscles could be moved voluntarily after treatment. No movement would have been obtained had all cells of the nucleus of the seventh nerve been destroyed. This impressed on him the necessity of keeping the muscles in good condition, so that the nerve can have something to move when its function returns. He feels that this is best accomplished by some form of heat, which causes capillary dilatation and thus increases the flow of blood and results in improved metabolic activity of muscles.

Stone<sup>78</sup> reports on 11 patients who received artificial fever or artificial fever combined with intraspinal injections of thiamine hydrochloride. Six of the patients received artificial fever and vitamins B complex and E orally, and 5 patients received intraspinal injections of thiamine hydrochloride besides artificial fever and vitamins given orally. The children treated had extensive involvement of the musculature of one or more extremities associated with generalized pain and muscular spasm and rigidity of the neck and back. Three of the children had previously received hot fomentations for from two to six weeks, without relief of tenderness and pain in the muscles or improvement of the paralysis. The average course consisted of four treatments, although 1 child received seven artificial fever treatments and four intraspinal injections. The intraspinal injections of thiamine hydrochloride were given in doses of 20 to 50 mg. eighteen to twenty-four hours prior to the artificial fever therapy. After the first treatment the patients had some relief of spasm, pain had decreased and nursing care was much easier. After several treatments they appeared stronger, were able to sit up without support for the first time and exhibited a greater range of movement because of freedom from pain. The skin of the affected extremities had lost its dry, mottled appearance. The color of the skin and the temperature were normal, and the extremities appeared alike, although one was severely paralyzed. In those muscles which were not completely paralyzed there was an increase in strength at one or two points. No contractures developed. All movements of the joints could be carried out without discomfort, and no deformities of the back had been evidenced up to the time the report was written.

75. Toomey, J. A.: Poliomyelitis and Neoprontosil, *Arch. Pediat.* 60:22-23 (Jan.) 1943.

76. McCormick, W. J.: The Mechanism of the Kenny Method and Its Correlation with Vitamin-B Therapy in Poliomyelitis, *M. Rec.* 155:525-527 (Dec.) 1942.

77. Toomey, J. A.: Effect of Infrared Heat on Localized Poliomyelitis and Neuritis, *J. Pediat.* 22: 135-141 (Feb.) 1943.

78. Stone, S.: Artificial Fever and Vitamin Therapy in Treatment of Anterior Poliomyelitis, *Arch. Phys. Therapy* 24:350-361 (June) 1943.

The thiamine hydrochloride was administered for its nonspecific beneficial effect on metabolism of the nerve cells. The intraspinal route was preferable because it placed the thiamine in greatest concentration closest to the affected cells in the spinal cord and affected nerve roots. When it was administered twelve to eighteen hours before the next artificial fever treatment better diffusion of thiamine in the nervous system was assured.

The action of artificial fever was also nonspecific. It increased the rate of blood flow through the body and central nervous system. The saturation of the blood was augmented. Improvement in cellular metabolism was produced. Catabolic products were removed at a greater rate.

The vitamin E was given for its beneficial results in the treatment of fibrositis. The vitamin B complex was used because of its supposed synergistic action with vitamin E.

It is suggested that combined vitamin-artificial fever therapy has all the advantages of hot fomentations besides a favorable influence on the regeneration of some neurons not completely destroyed by the virus.

Kabat and Knapp<sup>79</sup> found that muscular rigidity and hyperirritable stretch reflexes in poliomyelitis disappeared temporarily during spinal anesthesia. On the other hand, intravenously administered pentothal sodium produced relatively little effect on spasm in muscles. These studies suggest that spasm may be the result of changes in the gray matter of the spinal cord due to invasion of the virus. They state that this view is corroborated by Schwartz and Bouman.<sup>80</sup> Kabat and Grenell,<sup>81</sup> in making a pathologic study of the spinal cord in human poliomyelitis, examined 78 patients who died in the acute stage of the disease. Inflammatory reactions about the internuncial neurons in the gray matter were noted in almost every case and constituted the most prominent pathologic change in most cases. Little or no injury to the anterior horn cells was observed in about 40 per cent of the cases, while in the other 60 per cent there was more or less destruction of large motor neurons. Since all impulses through reflex arcs as well as from higher centers, including the pyramidal tracts,

must be relayed through the internuncial neurons to excite the large motor neurons in the anterior horn, they suggest that a lesion in these internuncial fibers should interfere with and disorganize synaptic transmissions to the anterior horn cells. This synaptic disorganization, which causes the removal of inhibition from the anterior horn cells, could account for the hypertonus and the incoordination. The effect of physostigmine and of neostigmine is to depress the function of an enzyme called cholinesterase. This enzyme is responsible for the rapid splitting of acetylcholine, rendering this powerful substance physiologically inactive. Thus neostigmine allows acetylcholine to accumulate to a greater extent than normal at synapses, parasympathetic nerve endings and myoneural junctions. With their pathologic observations and the effect of neostigmine as a basis, Kabat and Knapp<sup>82</sup> gave neostigmine methylsulfate or neostigmine bromide to a series of 24 patients who had had poliomyelitis from three weeks to seventeen months. It was necessary to give atropine sulfate along with the neostigmine except to patients under 6 years of age. For 20 of these patients the results were encouraging. Given with the Kenny method of treatment, the drug increased the range of passive motion, decreased or eliminated deformities in some instances by relaxation of hypertonus and in some cases improved active motion. In a majority of cases the drug appeared to accelerate recovery. In a number of cases the spasm was decreased more rapidly when given with the Kenny routine.

Galloway<sup>83</sup> cites 3 cases, in 2 of which life was undoubtedly saved by tracheotomy; in the third case life could perhaps have been saved had tracheotomy been performed ten minutes earlier. He points out that the normal secretion of saliva is from 1,000 to 1,500 cc. per day. This may be increased in certain nervous diseases. To this normal amount of secretion in anterior poliomyelitis may be added inflammatory nasal, pharyngeal and perhaps bronchial secretions. If this fluid cannot be completely expectorated, coughed out, swallowed or aspirated, it will gravitate to a level and obstruct the airway. This mechanical block produces anoxia, with a tendency to atelectasis and pneumonitis. If relief cannot be obtained by ordinary postural drainage and aspiration with the patient lying face down, tracheotomy followed by aspiration through the artificial opening is indicated. Use of the res-

79. Kabat, H., and Knapp, M. E.: *The Mechanism of Muscle Spasm in Human Poliomyelitis*, to be published.

80. Schwartz, R. P., and Bouman, H. D.: *Muscle Spasm in the Acute Stage of Infantile Paralysis as Indicated by Recorded Action Current Potentials*, J. A. M. A. **119**:923-926 (July 18) 1942.

81. Kabat, H., and Grenell, R. G.: *The Pathology of the Spinal Cord in Human Poliomyelitis*, to be published.

82. Kabat, H., and Knapp, M. E.: *The Use of Prostigmine in the Treatment of Poliomyelitis*, J. A. M. A. **122**:989-995 (Aug. 7) 1943.

83. Galloway, T. C.: *Tracheotomy in Bulbar Poliomyelitis*, J. A. M. A. **123**:1096-1097 (Dec. 25) 1942.



pirator is no contraindication for tracheotomy, as a special device can be made to keep the rubber collar off the opening of the tracheotomy tube.

*Experimental Studies for the Evaluation of Physical Therapy in Poliomyelitis.*—Abramson, Flachs, Freiberg and Mirsky<sup>84</sup> measured the rate of blood flow during rest by the venous occlusion plethysmographic method in a series of 27 subjects with acute or chronic anterior poliomyelitis of one extremity. In the majority of cases the peripheral circulation in the involved extremity was the same as, and in some cases it was greater than, that in the opposite side. The cutaneous blood vessels in the affected extremity responded more markedly to the stimulus of cold than did those of the normal limb. This was shown by the excessive vasoconstriction on exposure to a low environmental temperature with an apparent decrease in cutaneous temperature. Those treatments which have previously been used to increase the blood flow through the affected parts should be reexamined for their therapeutic value.

Molander and Weinmann<sup>85</sup> made a study of 8 patients with poliomyelitis which developed in the summers of 1939 and 1942. Their study consisted of carrying the various joints through a short arc of motion (the range of motion extending to the point where resistance could be felt) in one group of patients and of carrying the joints through a full range of motion in the other group of patients. The rate of recovery was much greater in those for whom the joints were carried through the long arc of motion than in those for whom the joints were carried through the short arc. The full passive range of motion was reached much earlier with the "long arc" treatment, and with the "short arc" treatment the same range was reached much later and only after forced stretching and manipulation under anesthesia. Examination of the muscles showed that the recovery of muscular strength was in no way impaired by too much strain on the muscles stretched by the full range of motion. The authors' results show that use of the full unrestricted arc of movement causes no harm and, in fact, has certain advantages over use of the short restricted arc of movement.

In an effort to further elucidate the Kenny concept of muscular spasm, mental alienation and

incoordination, Watkins, Brazier and Schwab studied the electrical discharges of muscles while at rest, during passive stretching and during voluntary contraction, both in early and in late stages of poliomyelitis. Comparing these results with similar studies on normal controls and on patients with traumatic lesions of peripheral nerves leads them to conclude that the Kenny concepts of muscular involvement in poliomyelitis, although the basis of an excellent type of treatment, are inadequate as a physiologic explanation of the dysfunction present. In the acute stage only muscles with some degree of paralysis discharge electrical potentials while at rest. These abnormalities are not correlated with the presence of clinical spasm. Partially paralyzed muscles were found to be hyperirritable to passive stretching, indicated both by electrical discharges and by pain. The muscular tension thus developed appeared to be a reflex protective mechanism. The electrical activity in weak muscles at rest increased during the period of improving motor power, and results were analogous to those seen in muscles during regeneration of peripheral nerves. When the improvement in motor power ceased, spontaneous electrical discharges disappeared. No abnormal electrical activity is associated with a true muscular contraction, nor are any discharges present in completely paralyzed muscles. In their cases muscular weakness could not be attributed to mental alienation, since the subjective signs of the infective processes were always present in the paretic antagonists of muscles in spasm. Their studies uphold the use of the term "incoordination," but they feel that "disordered reciprocal innervation" is a more descriptive term for this type of dysfunction.

Moldaver<sup>87</sup> carried out an investigation on 49 patients to see whether or not the Kenny concept actually existed and, if present, whether these symptoms had been overlooked for more than a century. The "spasm" was studied by electromyograms and "mental alienation" chiefly by chronaxia. Chronaxia is a means of determining the degree of neuromuscular degeneration in a paralyzed muscle. He concludes that spasm in muscles is not the most damaging symptom of infantile paralysis and does not lead to neuromuscular degeneration. Spasm is not an entity but a complex phenomenon and results from the

84. Abramson, D. I.; Flachs, K.; Freiberg, J. A., and Mirsky, I. A.: Blood Flow in Extremities Affected by Anterior Poliomyelitis, *Arch. Int. Med.* **71**:391-396 (March) 1943.

85. Molander, C. O., and Weinmann, B.: Results of the "Long Arc" and the "Short Arc" Treatment in the After-Care of Poliomyelitis, *Arch. Phys. Therapy* **24**: 74-87 (Feb.) 1943.

86. Watkins, A. L.; Brazier, M. A. B., and Schwab, R. S.: Concepts of Muscle Dysfunction in Poliomyelitis. Based on Electromyographic Studies, *J. A. M. A.* **123**: 188-192 (Sept. 25) 1943.

87. Moldaver, J.: Physiopathologic Aspect of the Disorders of Muscles in Infantile Paralysis: Preliminary Report, *J. A. M. A.* **123**:74-77 (Sept. 11) 1943.

combination of the normal stretch reflex, meningeal irritation of the posterior roots, increase of normal tonus in healthy and strong muscles opposed to weaker paralyzed muscles and lesions of the dorsal root ganglion in the posterior horns. He states in his conclusions that in alienated muscles there is neither a functional paralysis nor a physiologic block. The partial or complete loss of the power to control is due to damage or destruction of anterior horn cells. He always found some degree of neuromuscular degeneration in the paralyzed muscles which were considered alienated. He further concludes that incoordination does not consist in a misdirection of nerve impulses but is caused, if at all, by the inability of partially or totally denervated muscles to respond to otherwise normal nerve impulses.

*Kenny Method.*—Miss Kenny,<sup>88</sup> in her article in the *Physiotherapy Review* for January-February 1943, uses the space allotted her not so much for discussing her concept of the disease as for presenting a review of her difficulties in the past and her beginnings in this country and for reporting the evidence that attempted to prove to the medical committee which visited her on Nov. 22 and 23, 1942 that her concept of the disease was correct.

Bennett<sup>89</sup> describes the Kenny concept of infantile paralysis and the Kenny method of treating the triad of symptoms.

He<sup>90</sup> points out the change in the original Kenny concept of the disease as published in 1937. He feels that the success of her method of treatment in Minneapolis must in no small part be credited to the able support of the medical profession working with her. He states that medicine owes a debt to Miss Kenny for her keen perception and devotion to the cause of treatment of poliomyelitis, which can be repaid only by an equally keen and devoted research designed to support or if necessary to intelligently alter that treatment which she and other serious investigators have introduced. To disagree on certain details of technic is a healthy attitude and a spur to continue research, but therapy must be based on sound, proved physiologic and pathologic effects as well as on brilliant results before it is

right to say that it is the only treatment and that all others are wrong.

In discussing the influence of the Kenny concept of acute poliomyelitis on physical treatment throughout all stages of the disease Bennett<sup>91</sup> concludes:

While the full acceptance of the Kenny concept is hampered by poor terminology and by our limited knowledge of many of the basic physiologic and pathologic facts responsible for the cause and the after-effects of poliomyelitis, it is proving itself clinically sound. In the acute stage of the disease this concept presents a syndrome of clinical manifestations which may lead to widespread weakness and deformity unless immediately recognized and treated. No one of these clinical manifestations is new in the sense that it had never been seen before, but the full significance of the triad making up the syndrome had not previously been appreciated. It is evident that, since we had not been aware of the full significance of these clinical findings, our past forms of treatment are likely to be inadequate and must either be discarded or be modified in ways consistent with the new concept. We must not confuse the Kenny concept with the Kenny method. The Kenny concept is a presentation of clinical findings in the acute stage of the disease. The Kenny method is an attempt to treat these findings.

In the convalescent stage the concept explains the cause of the development of contractural deformities and the spotty return of muscle power, and in this way indicates certain routines of treatment. These routines may be similar to those used in the past, but the reasons for their use may be quite different. In this stage there must be no temporizing in the face of beginning periarticular and intramuscular contractures. We have in the past learned how to deal with these contractures. We must not sit idle and hope that hot packs will dissolve the contractures in some magical manner. If they do not quickly respond to conservative measures they must be stretched out manually or even wedged out in plaster casts. We have long known the danger of allowing patients to bear weight and increase their activity unless correct structural alignment can be maintained. When the patient's activity should be increased and protective or supportive apparatus is indicated, such apparatus should be utilized as long as is necessary. Our statistical results may suffer but our patients won't.

In the chronic phase of the disease the concept helps explain the results and perhaps points out the inadequacies of past treatment, but it solves the treatment problem in no way.

Bingham<sup>92</sup> gives a preliminary report on the treatment of a total of 60 patients with infantile paralysis at the Country Branch of the New York Orthopaedic Dispensary and Hospital. These patients were divided into three groups: (1) those having only Kenny treatment. (2) those

88. Kenny, E.: Kenny Concept of the Disease Infantile Paralysis, *Physiotherapy Rev.* 23:3-7 (Jan.-Feb.) 1943.

89. Bennett, R. L.: Recent Developments in the Treatment of Poliomyelitis, *South. M. J.* 36:152-156 (Feb.) 1943.

90. Bennett, R. L.: Basis for Physical Therapy in Acute Poliomyelitis, *Virginia M. Monthly* 70:15-18 (Jan.) 1943.

91. Bennett, R. L.: The Influence of the Kenny Concept of Acute Poliomyelitis on the Physical Treatment Throughout All Stages of the Disease, *Arch. Phys. Therapy* 24:453-460 (Aug.) 1943.

92. Bingham, R.: The Kenny Treatment for Infantile Paralysis: A Comparison of Results with Those of Older Methods of Treatment, *J. Bone & Joint Surg.* 25:647-650 (July) 1943.

receiving Kenny treatment late in the course of their illness and (3) those having only the older methods of therapy. Follow-up studies were made three months later. He concludes:

Patients receiving the Kenny treatment are more comfortable, have better general health and nutrition, are more receptive to muscle training, have a superior morale, require a shorter period of bed rest and hospital care, and seem to have less residual paralysis and deformity than patients treated by older conventional methods. The Kenny treatment is the method of choice for the acute stage of infantile paralysis.

[ED. NOTE.—I do not consider this a conclusive study, as three months is not a sufficient follow-up period in which to conclude that deformities will not occur.]

Northway<sup>93</sup> discusses his observations of Miss Kenny's method of treatment and not his experience with this treatment on a group of patients. He describes Miss Kenny's conception of muscular spasm, mental alienation, incoordination and treatment. His conclusions are:

The Kenny method of treatment is most successful when used during the acute stage of the disease.

Pain and muscle spasm are relieved and permanent contractures are prevented.

Muscle tissue is kept in a physiological state receptive to muscle education and a return of function, provided anterior horn cells have not been permanently or too completely destroyed.

Permanent paralysis is not prevented in the presence of massive anterior horn cell destruction.

O'Donoghue<sup>94</sup> feels that a great deal of criticism directed at the Kenny method of treatment is due to the method of presentation rather than to the material that has been presented. Sister Kenny's personality is a factor. He states that after considerable study and a minimum of observation the method appears to offer a definite improvement in the treatment of poliomyelitis. He is, however, equally convinced that with improper facilities and untrained personnel the Kenny method will do more harm than good and that without appreciation of this fact by the physician the method will rapidly fall into disrepute. He presents no comparative study.

Stuck and Loiselle,<sup>95</sup> in giving reports for the 1942 epidemic of poliomyelitis in San Antonio, Texas, report a total of 87 cases. The symptoms responsible for the diagnosis of poliomyelitis were fever, headache, stiff neck, stiff

back and muscular weakness. Sixty-two patients had a paralytic type of the disease, while 25 had an abortive type and had no muscular weakness. All the patients who showed any muscular tenderness or weakness, stiffness of the back or hypertonus of muscles were given treatment as outlined by the Minneapolis group. Intensive treatment was abandoned only after all hyperirritability and pain of the muscles were overcome. Reexamination of all patients in January 1943 revealed that 30 patients were free from all effects of the disease, with no muscular weakness or hypertonus of any muscle group. These included the 25 who had an abortive type or only temporary weakness. Sixteen others had slight residual weakness. Twenty-nine had moderate to severe residual weakness. Six patients died, and results were unknown in 6 cases. Only 53 per cent of the patients, including those with the abortive type and those with only slight residual weakness, completely recovered. However, it is stated that follow-up examinations revealed more rapid recovery than usual among those who were not severely paralyzed at the onset, and indications were that there would be less residual deformity than usual.

Reporting on the first year of treatment at the Iowa Lutheran "Kenny Cottage," a pavilion of the hospital dedicated by Miss Kenny for the treatment of acute infantile paralysis during the contagious stage, Dyson<sup>96</sup> gives data on the results of treatment of 39 patients.

There was 1 death. Twenty-three patients remained in the hospital from one to two months; 10 remained in the hospital from three to five months; 5 were still in the hospital or remained there as long as seven months.

There were 25 complete recoveries; 3 patients had slight residual weakness and 10 marked residual weakness.

Patients who remained in the hospital two months or less made a complete recovery (with the exception of the 1 who died). Only 2 recoveries were reported for patients remaining more than two months. Three other patients, remaining three to five months, had slight residual weakness, and the remaining 10 had rather pronounced residual weakness. [ED. NOTE.—The important point is that in 23 of the 25 patients complete recovery took place within two months. Therefore only 2 of 25, or 8 per cent, needed treatment for longer than two months for complete recovery. It is apparent that most of the complete recoveries

93. Northway, W. H.: *The Kenny Method of Treatment of Poliomyelitis*. Stanford M. Bull. 1:171-174 (Aug.) 1943.

94. O'Donoghue, D. H.: *A Consideration of the Kenny Treatment of Infantile Paralysis*. J. Oklahoma M. A. 36:236-238 (June) 1943.

95. Stuck, W. G., and Loiselle, A. O.: *The 1942 San Antonio Poliomyelitis Epidemic*. J. A. M. A. 122:853-855 (July 24) 1943.

96. Dyson, J. E.: *The Kenny Treatment in Acute Poliomyelitis: A Report of the First Year at the Iowa Lutheran Kenny Cottage*. J. Iowa M. Soc. 33:372-373 (Aug.) 1943.

attributed to the method of treatment occurred in patients with a nonparalytic form of the disease or in persons who would have made a spontaneous recovery.]

Toomey<sup>97</sup> presents an excellent article on the basic considerations needed for judging therapeutic results in infantile paralysis. An abstract of this entire article would be too extensive for this review. But his classification of patients, I think, is of sufficient interest to be quoted verbatim. He states that persons in whom the virus of poliomyelitis is present can be divided into nine groups:

Group 1. Those who have the virus in the gastrointestinal tract and who exhibit no symptoms. The number in this group will probably be great during epidemics.

Group 2. Those with virus in the gastrointestinal tract who merely have gastroenteritis (diarrhea or constipation), headache or some other nonspecific disturbance and no other symptoms.

Group 3. Those who have the aforementioned symptoms plus nausea and even pain in the belly. Groups 2 and 3 have what are termed abortive forms of the disease, and these patients too may be considered numerous.

Group 4. Those who have symptoms and significant changes in the spinal fluid but no paresis or paralysis.

Group 5. Those who in addition to the aforementioned symptoms have a positive Kernig sign (tightness of the muscles; hamstring tension of the posterior muscles of the hamstring group), a stiff back and no paresis or paralysis.

Group 6. Those who, in addition to a positive Kernig and a positive Brudzinski sign and a stiff back, have a stiff neck, some with marked opisthotonos. Groups 4, 5 and 6 are sometimes classified as "non-paralytic." They have no paresis or paralysis.

Group 7. Those who have all the previous signs and symptoms plus some segmental muscular paresis, which can be appreciated only on careful examination—a paresis not accompanied by any functional impairment or synchronous movement.

Patients in groups 2 to 7 inclusive arrive in a hospital for persons with contagious disease and usually recover within the isolation period of twenty-one days and are discharged cured. They rarely need to see an orthopedic surgeon; they rarely require any physical therapy other than that received in the hospital.

Group 8. Those who have all the signs and symptoms previously mentioned plus some obvious segmental weakness which does not fully approach paralysis and which does not interfere with synchronous rhythmic motion.

Group 9. Those who in addition to all the aforementioned signs and symptoms have a typical lower motor neuron lesion with segmental paralysis. Years ago it was rare that a patient got into a hospital unless he belonged to this group. At the present time, in communities which have become conscious of poliomyelitis conditions of diagnosis have so improved

that in epidemics many patients with abortive, non-paralytic forms of the disease and patients with paresis belonging in groups 2 to 7 inclusive are recognized. They may constitute the majority of persons that are admitted to the hospital during an epidemic; in one of the epidemics in Cleveland they made up nearly 80 per cent of the patients, and in no epidemic have they constituted less than 30 per cent.

The patients in groups 8 and 9, those with paresis or paralysis, are admitted to the hospital and later cared for by the orthopedic surgeon and the physical therapist. In the future these will still be the only patients whom these specialists will see or in whom they will be interested.

Good results of any new therapy must be shown in the patients in groups 8 and 9. If other methods give equally good results and are less expensive they become the methods of choice. Patients within groups 1 to 7 inclusive who are given physical therapy during the period of isolation in the contagious disease hospital no doubt have an important bearing on the unusual recovery rate reported in recent epidemics. Toomey states that if one has 100 patients with infantile paralysis of whom 20 per cent are in groups 8 and 9 and 80 per cent in groups 2 to 7 inclusive, it is known that 80 will get well no matter what is done. If the entire group of 100 is treated, the recovery rate is 80 per cent to start with—a fictitious rate to attribute to any therapy.

Lenhard,<sup>98</sup> in reporting on the 1941 epidemic in Maryland, describes a study of 296 cases of poliomyelitis. Sixty-eight per cent of the patients made a complete recovery. Fourteen per cent had slight residual weakness. Only 2 per cent had complete disability. There were 9 deaths. Treatment consisted of protective care and physical therapy for weak muscles. There was no complete immobilization of the patients or of the extremities. There was usually continuous improvement of the muscles. As a rule, they did not remain unchanged for three or six months and then show increased power. Patients who did not recover rapidly or spontaneously needed prolonged treatment for recovery of maximum power in the weak muscles. Muscles do not improve in direct ratio to the degree of initial weakness. They may continue to improve for eighteen months in patients who are treated immediately after the onset of the disease. Patients seen later improve up to nine months.

Rechtman<sup>99</sup> describes in detail the "orthodox" system of treatment of infantile paralysis, particularly as carried out at the Betty Bacharach

98. Lenhard, R. E.: The Results of Poliomyelitis in Baltimore, *J. Bone & Joint Surg.* 25:132-141 (Jan.) 1943.

99. Rechtman, A. M.: Analysis of Treatment of Infantile Paralysis, with Comments on Kenny System, *Arch. Phys. Therapy* 24:461-471 (Aug.) 1943.

97. Toomey, J. A.: Poliomyelitis: Basic Considerations Needed for Judging Therapeutic Results, *Am. J. Dis. Child.* 66:635-651 (Dec.) 1943.

Home. This method is the same or similar to generally accepted modes of treatment as practiced at the Georgia Warm Springs Foundation and in other places where a number of patients with infantile paralysis are admitted. It is the author's hope to make a comparison of the results of the study in the Betty Bacharach Home with the orthodox method of treatment and the results obtained with the treatment introduced by Sister Kenny. There is a general discussion on the Kenny method of treatment of infantile paralysis, which is a recapitulation of Miss Kenny's work. It is the author's impression that treatment of the acute phase of infantile paralysis will for the most part revert to the previous methods used at the Betty Bacharach Home and will incorporate those measures suggested by Miss Kenny that have proved of value. In either system, however, the final results depend on the expertness and the training of the person giving the treatment.

Key<sup>100</sup> compares the Kenny and the orthodox method of treatment of infantile paralysis. He discusses Miss Kenny's and the orthodox conception of spasm, incoordination and mental alienation. He concludes:

The most important difference between the Kenny and the orthodox methods of treating poliomyelitis is that in the Kenny method emphasis is placed upon muscle spasm as the most important feature of the disease and efforts are made to relieve this spasm by hot fomentations, while in the orthodox method flaccid paralysis of muscles is considered the most important feature of the disease and efforts are made to protect and restore function to the paralyzed muscles. The other two symptoms which are stressed by Miss Kenny (incoordination and mental alienation) are recognized under different names, but are treated in much the same manner under each method. However, we believe that early active exercise of muscles is harmful and tends to prolong the stage of tenderness and contracture and we do not begin our muscle training until these symptoms have subsided, while Miss Kenny begins her muscle training as soon as possible after the diagnosis of poliomyelitis is made. We also consider splints a useful adjunct to our treatment where they are indicated.

The symptoms which Miss Kenny calls muscle spasm are recognized and treated in the orthodox method, but they are called rigidity and muscle contracture and are treated by immobilization in splints or casts to relieve the pain and prevent contractures and the development of deformities. In anticipation of the criticism that even though orthodox treatment has recognized the so-called muscle spasm it has failed to emphasize and treat this symptom, I wish to state that rest is probably the most important therapeutic measure in our armamentarium and that in order to put a muscle at rest we immobilize the part. Consequently, we treat the tender, painful, contracting muscles by

rest. This is obtained by our splints or casts. The reason we have not emphasized these symptoms is that they tend to subside when the limb is put at rest. The tendency of the muscles to contract (so-called muscle spasm) subsides when the pain and tenderness disappear and if deformities are prevented this symptom is rarely an important problem under orthodox treatment. It has not been emphasized because it subsides spontaneously.

Key<sup>101</sup> describes his conception of the standard treatment of infantile paralysis. He calls it: economical or common sense method and cites the under-water gymnasium of Lowman and the institute at Warm Springs and the prolonged protection of paralyzed muscles, combined with intensive physical therapy, as practiced by the Kendalls in Baltimore, as variations of the standard method. He cites twenty-eight reasons why the orthodox method described by him is superior to the Kenny treatment of poliomyelitis. He severely criticizes the statistics which show cure for 80 per cent of patients receiving the Kenny treatment as compared with 12 per cent receiving orthodox treatment, according to McCarroll figures. The 80 per cent in the Kenny series include all the patients who make a spontaneous recovery. He declares that the proponents of the Kenny method do not recognize spontaneous recovery. The percentage cited by McCarroll include patients who had residual paralysis of sufficient degree to cause them to go to a hospital for treatment, and no temporarily paralyzed patients were included in the group.

Bohnengel<sup>102</sup> describes the Kenny concept of infantile paralysis and states that psychobiologic disorganization coexists with an anatomic-physiologic disorganization in acute infantile paralysis. He states:

Although the Minneapolis group has never denied the occurrence of paralysis, they have, apparently under the influence of Miss Kenny, tended to minimize its importance in the clinical picture of infantile paralysis. This tendency undoubtedly arises from the realization that nothing is to be accomplished by treating a symptom which is the direct result of an irreversible structural lesion, whereas there is much to be gained by focusing attention on a reversible symptom which has proved amenable to treatment. The tendency, however, to minimize the importance of paralysis has been unfortunate. It has helped create a controversial situation in which much energy is being expended to prove on the one hand that paralysis and on the other that "mental alienation" is the disabling symptom, whereas the essential problem is to what extent each plays a role. Nevertheless, much new data have resulted from this controversy, and it is increasingly

101. Key, J. A.: Reasons Why the Orthodox Is Better Than the Kenny Treatment of Poliomyelitis. *Surg., Gynec. & Obst.* 77:389-396 (Oct.) 1943.

102. Bohnengel, C.: Psychobiologic Factors in the Kenny Concept of Infantile Paralysis, *Arch. Phys. Therapy* 25:350-356 (June) 1944.

100. Key, J. A.: The Kenny Versus the Orthodox Treatment of Anterior Poliomyelitis, *Surgery* 14:20-31 (July) 1943.

apparent that the arguments are much more in agreement than are their respective proponents. Although there is sufficient well substantiated evidence that both symptoms do exist, there are many wide gaps in our knowledge of each.

The crux of the whole controversy over the Kenny concept lies in the fact that one group of observers, principally the Minneapolis group, is using psychobiologic methods of observation, experimentation and treatment and therefore brings into view only those of phenomena which exist at the psychobiologic level of organismic integration. The other group, using more purely physical methods of study, brings into its field of vision only those phenomena which exist at the anatomic-physiologic level of organismic integration. Both groups tend to lose sight of the fact that the two symptoms may be coexistent not only in the same individual but in the same muscle. It is important to subject the method of procedure to critical study before attempting an evaluation of the facts, a principle somewhat more rigidly adhered to in laboratory investigations than in clinical investigation.

*Paralytic Scoliosis.*—Farkas<sup>103</sup> gives an excellent description of the early clinical manifestations of paralytic scoliosis. He describes in detail the mechanical factors entering into the formation of the different curves. He states that a few weeks or months after the onset of infantile paralysis the spine discloses changes representing a pathologic entity—the paralytic spine. It is necessary to speak of paralytic spine instead of scoliotic spine since at the onset there is no lateral deviation; but the spine discloses significant features, as follows:

1. At the onset we observe enlargement of the intervertebral spaces, followed later on by dullness and cloudiness; the border lines between discs and vertebrae are effaced; and the spaces themselves become uneven and appear markedly narrowed. Ossification of the epiphyseal ring starts in some cases as early as the age of four; the process is very irregular, and the ossification is bulky and confluent. Minute or larger calcium deposits appear in the intervertebral spaces. This process may last for years, accompanied by general bone atrophy; in many cases after a couple of years the process apparently heals spontaneously.

2. Functionally, the paralytic spine is characterized by a high degree of flexibility and compressibility. Because of the increased mobility, univertebral or segmental rotations appear first without any lateral deviation. Due to the flexibility, forward-backward tilting of one or more vertebrae occurs with the disappearance of thoracic kyphosis and lumbar lordosis. As a result of the increased mobility and compressibility—the prime factor in the formation of scoliosis—a translatory shift of the vertebrae appears.

The paralytic spine is the pathological condition preceding paralytic scoliosis. The scoliotic curve requires usually from four to five years before reaching its final form. Prior to this, the side of the convexity and the direction of the rotation may change several times. The rotation and compression of the spine are the chief factors in preparing the way for paralytic scoliosis.

The rotation is brought about by faulty mechanics of:

- (a) the pelvis (pelvic rotation); (b) the thorax and

shoulder girdle (thoracic rotation); and (c) the respiration.

In pelvic rotation, all spinous processes point to the same side of the body. In thoracic rotation, the thoracic and the lumbar spinous processes point in opposite directions.

The cause of rotation is the pathological imbalance between the two sides of the body carrying out rotary motions of different degrees during the performance of the daily routine, especially during locomotion. The physiological imbalance, present in every human being, takes advantage of the decreased resistance of the rotary system of the spine—that is, damage of the discs—and causes the predominance of the right thoracic, left lumbar curves.

Paralytic scoliosis is brought about by the imbalance between the two sides of the body exerted on the paralytic spine. Paralytic scoliosis can be differentiated from scoliosis of any other etiology by the uniform density of the spine in the roentgenogram, by the excessive and early rotation of the vertebrae, and by the temporary concave rotation.

Curves resulting from pelvic rotation, except for the sitting curves, have a far better prognosis than the thoracic curves, especially if the latter are associated with respiratory disturbances.

*Operations.*—Girard<sup>104</sup> presents another method designed to lessen the disability brought about by fixed paralytic pelvic obliquity. In 3 cases he transplanted the origin of the hamstrings on the low side of the pelvis to the symphysis pubis. This transplant apparently lengthened the arm of the lever on which the adductors functioned and thereby increased their strength, necessary for better pelvic balance. He points out the importance of correcting the pelvic obliquity before attempts are made to correct the scoliosis of which the pelvis is a part. [ED. NOTE.—In true fixed paralytic pelvic obliquity no one operative procedure will fulfil all requirements necessary for restoration of anatomic alinement. There is always as much fixation above the pelvic level as there is below. In the majority of cases the abductors are contracted on the low side of the pelvis and the adductors and the lateral trunk group are contracted on the high side of the pelvis. In persons in whom this deformity has existed over a long period I do not believe it is possible to restore anatomic alinement by any operative procedures. There are too many widespread structural changes. These patients can be helped by improving the faulty distribution of weight of the superstructure. This can be accomplished by shifting the femoral shaft on the high side of the pelvis toward the midline by subtrochanteric osteotomy and shifting the femoral shaft on the low side of the pelvis in a lateral plane by subtrochanteric osteotomy. These

103. Farkas, A.: Paralytic Scoliosis, *J. Bone & Joint Surg.* 25:581-612 (July) 1943.

104. Girard, P. M.: Paralytic Pelvic Obliquity: Transplantation of Origin of Hamstring Muscles to Symphysis Pubis, *J. Bone & Joint Surg.* 25:169-176 (Jan.) 1943.

procedures do not in any sense correct the scoliosis and the obliquity of the pelvis, but they do enable the patient to walk with less effort and in a more orderly manner.]

Billig and van Harreveld<sup>105</sup> make a preliminary report on a new aspect of reinnervation of muscles, which heretofore has not been presented. This work is based on the fact that more than a normal amount of muscle can be innervated by a nerve by causing the motor axons to divide more extensively than they normally do and thus to innervate paretic muscle tissue. He states that a regeneration of nerve fibers in general is accompanied by branching. The first operation was on a 16 year old boy, who had a three year history of poliomyelitis, with residual drop foot on one side. It was carried out approximately two years prior to the time the article was written. The treatment consisted in crushing motor branches of the peroneal nerve. This was done with a Kelly clamp placed as close to the innervation as possible. This operation, of course, resulted in complete paralysis of the involved muscles until the time the motor axons had again grown out from the point of interruption and established contact with the muscle fibers. This regeneration required approximately two months. Immediately after the operation a short drop foot brace was applied, and no phys-

ical therapy was given. He states that at the present time the boy has full functional power in the leg and foot—that the atrophied muscles have regained their size so that external measurements of the leg's circumference closely approximate that of the unaffected leg. In the other case in which there was involvement of both lower extremities the femoral nerve was crushed as near the nerve as possible and the tibial nerve was crushed in the popliteal region. No physical therapy was given for three months. By this time the muscles had recovered more power than had been present prior to operation. The authors state that the patient has gained sufficient strength to walk correctly without a brace which was necessary prior to operation. One hundred and two additional operations have been done, the data on which are not complete.

The open incision has been largely replaced by manual methods, in which the muscles are vigorously kneaded by smooth blunt instruments, particularly in the area where the motor axons enter the muscle. In the first patient on whom this was done the postoperative course approximated that for direct interruption of the axons. Nine months later his muscular power was slightly greater than that previous to the time of treatment. The advantage of manual pressure over actual crushing is that all the motor axons are not interrupted and temporary total paralysis does not result. It was estimated that the rate of reinnervation was 4 mm. a day.

105. Billig, H. E., and Van Harreveld, A.: A New Aspect of Muscle Reinnervation: A Preliminary Report, U. S. Nav. M. Bull. 41:410-414 (March) 1943.

*(To Be Continued)*

## EXPERIMENTAL TOURNIQUET SHOCK WITH PARTICULAR REFERENCE TO THE TOXIC FACTOR

A METHOD OF PRODUCTION ELIMINATING THE INFLUENCE OF GENERAL ANESTHESIA AND NERVOUS IMPULSES

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In any experimental study of shock, simplicity and uniformity of production are admittedly essential factors. We agree with Allen<sup>1</sup> and Moon<sup>2</sup> that the tourniquet technic probably meets these requirements more easily than any other method, such as trauma to a hindlimb, burning, intestinal manipulation or hemorrhage. Nevertheless, the serious criticisms of the influence of anesthesia and of nervous impulses in the production of experimental shock have been applicable to practically all tourniquet methods heretofore used. It seemed desirable in our study of the problem to overcome these objections as much as possible before attempting to gather evidence either for or against any of the three currently accepted theories as to the cause of shock: (a) local loss of circulating fluid (Blalock and Duncan,<sup>3</sup> Parsons and Phemister,<sup>4</sup> Wilson and Roome<sup>5</sup> and Mann and Mann and

Essex<sup>6</sup>); (b) absorption of a toxic substance from injured areas (Dale and Laidlaw and Dale, Laidlaw and Richards,<sup>7</sup> Cannon and Bayliss and Cannon,<sup>8</sup> Green and Green and Bielschowsky<sup>9</sup> and Scudder<sup>10</sup>); (c) effect of nervous impulses (Phemister and associates,<sup>11</sup> Crile and Lower,<sup>12</sup> Cooper,<sup>13</sup> Simonart,<sup>14</sup> O'Shaughnessy

6. Mann, F. C.: Shock and Hemorrhage: An Experimental Study, *Surg., Gynec. & Obst.* **21**:430, 1915. Mann, F. C., and Essex, H. E.: The Present Status of the Problem of Shock, *Am. J. Surg.* **28**:161, 1935.

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11. Phemister, D. B.; Loester, C. H.; Eichelberger, L., and Schachter, R. J.: Afferent Depressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic Depressor Nerve Stimulation, *Ann. Surg.* **119**:26, 1944.

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(Footnotes continued on next page)

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2. Moon, V. H.: Shock: Its Dynamics, Occurrence and Management, Philadelphia, Lea & Febiger, 1942.

3. Blalock, A.: Principles of Surgical Care, Shock and Other Problems, St. Louis, C. V. Mosby Company, 1940. Blalock, A., and Duncan, G. W.: The Uniform Production of Experimental Shock by Crush Injury: Possible Relationship to Clinical Crush Syndrome, *Ann. Surg.* **115**:684, 1942; Traumatic Shock—A Consideration of Several Types of Injuries, *Surg., Gynec. & Obst.* **75**:401, 1942.

4. Parsons, E., and Phemister, D. G.: Hemorrhage and "Shock" in Traumatized Limbs, *Surg., Gynec. & Obst.* **51**:196, 1930.

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and Slome<sup>15</sup> and Freedman and Kabat<sup>16</sup>). Because of its simplicity and uniformity, the tourniquet method of producing shock is highly desirable, but it requires prolonged anesthesia, for dogs sometimes as long as twenty-four hours, to overcome the severe pain produced by the tourniquet while the experiments are being done. Often, anesthesia of such duration alone is sufficient to kill a dog. It was found practicable to produce severe shock in dogs by modifying the tourniquet method and eliminating the influences of anesthesia and nervous impulses. A description of the method follows.

#### METHODS AND RESULTS

*Production of Shock.*—With the animals under anesthesia induced by intraperitoneally administered pentobarbital sodium (32 mg. per kilogram of body weight), the spinal cord was completely divided between the thoracic and the lumbar region in a series of 10 dogs. By the second day the dogs were recovered sufficiently to take food and water. On the third or fourth day the hair was clipped and shaved over the left hip and the area scrubbed gently with 70 per cent alcohol. A square of gauze moistened with alcohol was placed over the area, its center being directly over the femoral trochanter, which is subcutaneous at that point. A thin sterile nail about 2½ to 3 inches (6 to 8 cm.) long, with its tip filed to a sharp point, was driven with a hammer through the gauze into the trochanter, the nail pointing distally and oblique to the shaft of the femur. Two to three turns of thin rubber tubing, such as is used for intravenous infusions, were wound tightly around the thigh at the groin above the nail, which prevented the tourniquet from slipping out of place; the ends of the tourniquet were tied together with cord. Previous section of the spinal cord obviated the necessity of anesthesia during or subsequent to this procedure. The tourniquet was sufficient to shut off all circulation to the hindlimb, so that no appreciable swelling occurred while the tourniquet was in place except in 1 or 2 instances. In these cases there might possibly have been some flow of blood through the femur or damage to perforating arteries in the femur by the nail in the interval before the tourniquet could be applied, since it seemed that in 1 case at least the leg was swollen immediately after the tourniquet was applied, and at post-mortem examination a blood clot was found beneath the skin. Ischemia of the hindlimb was maintained for from nine to twenty hours, after which the tourniquet was released. The dogs then rapidly entered into a state of shock, and all died. No evidence of infection was noted in the limb at the site of the puncture made by the nail. Blood pressure was determined before and periodically after release of the tourniquet in the femoral artery of the right hindlimb,

by the intra-arterial sphygmomanometer method. Blood samples were simultaneously taken for determinations of specific gravity (the falling drop method), hematocrit value and pyruvic acid. Changes in rectal temperature were also recorded.

Much effort has been expended in experimental work on shock to determine pathognomonic signs, but at the present time it is generally agreed that the only sign that is common to all types is a sustained fall in blood pressure. Other signs, such as hemoconcentration, increase or decrease in specific gravity of the serum, rise or fall in body temperature and tachycardia, vary with the type of shock. After application of the tourniquet and up to the time of its release the dogs appeared to be normal, except, of course, for paralysis of the lower part of the body and its effects, such as urinary and fecal incontinence. They appeared to be alert; they took food and water, and their respiratory rate, pulse rate and blood pressure were within normal limits. Just prior to the release of the tourniquet, the blood pressure was taken and was found to range between 90 and 120 systolic in the 10 dogs of this series. These figures compare well with those reported as normal (90 to 120) by Parkins,<sup>17</sup> in a study of the normal blood pressure in dogs, determined by the intra-arterial needle puncture method.

Although the manifestations of tourniquet shock in dogs have been reported previously, our findings will be listed, at least in slight detail, to indicate that section of the spinal cord did not alter significantly the development and the type of shock following release of the tourniquet. After release of the tourniquet all dogs immediately became restless. Within ten or fifteen minutes, the blood pressure fell 10 to 20 mm. of mercury and then rose, but in the animals of this series it never reached the normal value, which was determined for each dog just prior to release of the tourniquet. Then there was a gradual fall until death occurred, on an average two to two and one-half hours after release of the tourniquet. Usually within an hour the dog was noticeably lethargic and began to exhibit muscular twitchings in various parts of the body. However, the dog remained responsive until at least one-half hour before death, and lid reflexes were present almost to the point of death. The pulse, which before release of the tourniquet was strong and full, with a rate of 80 per minute, soon

13. Cooper, A.: *The Principles and Practice of Surgery*, Philadelphia, Cary and Hart, 1835.

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18. Evans, E. I.; Hoover, M. J.; James, G. W., and Alm, I.: *Studies on Traumatic Shock: I. Blood Volume Changes in Traumatic Shock*, Ann. Surg. **119**:64, 1944.

became rapid after release of the tourniquet and gradually became weaker, thready and more rapid, until it was practically impalpable one-half hour before death, when the rate was usually about 140 per minute or more. To obtain blood pressure readings when the pulse was impalpable, it was our policy to cut down on the femoral artery in the thigh and insert the needle under direct vision. Respiration, which was normal to begin with, became noticeably more rapid immediately after release of the tourniquet. It showed a tendency to return to normal and then gradually became more rapid and more shallow, until just before death breathing was deep and gasping, with retraction of the trachea. The heart may continue beating after respiration has ceased. Hematocrit determinations usually showed progressive increase in packed cell volume, while the specific gravity of the serum, as a rule, decreased (table).

The pyruvic acid level of the blood showed no significant change. The girth of the leg before and after release of the tourniquet was measured 2 inches (5 cm.) above the knee; the average increase in circumference measured about 0.5 cm. Comparative weights of the two hindlimbs, determined by a method to be described, averaged 21 Gm. per kilogram increase of body weight. Therefore, the average gain in weight in the constricted extremity represented 2.1 per cent of the body weight. Occasionally a dog had a hemorrhagic bowel movement just before death and spontaneously expelled a concentrated urine. Rectal temperatures showed a slight rise of 0.5 to 1 F. from the time of release of the tourniquet until death. Gross and microscopic observations at necropsy agreed with observations recently reported (Moon,<sup>2</sup> Blalock and Duncan<sup>3</sup>). The spleen was contracted, the liver, lungs and kidneys congested and the adrenal glands and the large bowel hemorrhagic. The data on these experiments are shown in the table.

#### EXPERIMENTS RELATED TO THE PATHO- GENESIS OF TOURNIQUET SHOCK (TESTING FOR TOXINS BY CROSS TRANSFUSION)

As will be discussed later, the amount of plasma lost into the dog's hindlimb after application and release of the tourniquet was only 2.1 per cent of the body weight. Since this amount is not considered sufficient to account for death on that basis alone, we decided to investigate the possibility of toxemia as a cause of death. Lymph collected from the thoracic ducts of animals suffering from crush injury has already

been found to be toxic (Blalock<sup>19</sup>). From a study of blood which had been removed from a dog dying from tourniquet shock it appeared to us that blood drawn from the general circulation would be too dilute to demonstrate toxicity. We therefore adopted methods to test the blood removed directly from the femoral vein draining the leg from which the tourniquet had been released.

These experiments, though entirely of a preliminary character, are reported now because exigencies of war have prevented their completion.

**EXPERIMENT 1.**—The spinal cord of each of 2 dogs was cut at the level of the lowest dorsal vertebra. After a lapse of three days for recovery from the chordotomy, 1 dog was given 5 mg. of heparin per kilogram of body weight, and a tourniquet was applied for sixteen hours. Cannulas were then inserted into the femoral vein above the tourniquet in both directions. After a similar dose of heparin was given to the other (control) dog, cannulas were placed in a femoral vein, one in each direction, and the tubes connected so that a cross transfusion could be performed from the limb to which the tourniquet had been applied to the limb of the control dog. The tourniquet was then released and cross circulation established between the 2 dogs. The blood pressure was 98 for the dog which had been subjected to application of the tourniquet and 90 for the other dog at the beginning of the transfusion. After fifty minutes the pressure was relatively unchanged but the rate of flow had decreased, perhaps because of partial clotting. With a syringe blood was then withdrawn from 1 animal and injected into the other. Only about 50 cc. had been interchanged by this method before the dog to which the tourniquet had been applied showed serious evidence of shock. It died one hour and fifty seconds after release of the tourniquet. The dog which received blood from the shocked dog died two hours and thirty seconds after the cross transfusion was started. Inability to determine just how much blood was interchanged is undesirable, even though a blood pressure of 90 for each animal before transfer of an equal quantity (measured by syringe) of blood is fairly good evidence that the shock in neither dog was due to loss of blood. Nevertheless, it was decided that in additional experiments the amount of blood transferred from 1 dog to another must be accurately measured.

**EXPERIMENT 2.**—Two dogs were prepared, as described previously, by chordotomy, from which they recovered. A tourniquet was applied to the hindlimb of 1 and left in place for sixteen hours. The femoral vein was cannulated above the tourniquet, which was then released, and the blood was collected in a sterile bottle, until the dog died two hours and ten minutes later. Approximately 800 cc. of blood was collected, while the dog was being given transfusions of the same amount of compatible heparin-treated blood through a superficial vein in the opposite hindlimb. The blood was stored overnight in a refrigerator, and the plasma, which amounted to 430 cc., was siphoned into a sterile vacuum bottle. It was given to a normal dog (whose blood was found to be compatible by blood-grouping and

19. Blalock, A.: A Study of Thoracic Duct Lymph in Experimental Crush Injury and Injury Produced by Gross Trauma, *Bull. Johns Hopkins Hosp.* 72:54, 1943.

*Data Illustrating Experimental Tourniquet Shock in Dogs Under Anesthesia Achieved by Section of the Cord \**

Dog No.	Sign	Before Release of Tourniquet	10 to 15 Min.	30 Min.	1 Hr.	1 Hr. and 30 Min.	2 Hr.	2 Hr. and 30 Min.	3 Hr.	At Death	Survival After Release of Tourniquet	Dog Weight, Kg.	Weight Gain of Constricted Extremity, Gm.	Percentage of Weight Gain
1	Blood pressure.....	120	80	51	..	..	38	29	..	0	2 hr. and 35 min.	11.5	255.1	1.75
	Hematocrit reading.....	52	..	58	..	..	63	..	..	63	..	..	..	..
	Specific gravity.....	1.0201	..	1.0200	..	..	1.0251	..	..	1.0251	..	..	..	..
	Rectal temperature.....	104	..	101	..	..	101.2	..	..	101	..	..	..	..
	Pyruvic acid, mg. %.....	0.45	..	..	..	..	..	..	..	0.175	..	..	..	..
2	Blood pressure.....	100	71	69	40	..	30	..	..	0	2 hr.	10.9	220.8	2.07
	Hematocrit reading.....	53	..	57	..	..	..	..	..	62	..	..	..	..
	Specific gravity.....	1.0250	..	1.0211	..	..	..	..	..	1.0238	..	..	..	..
	Rectal temperature.....	103	..	103	..	..	..	..	..	103.1	..	..	..	..
	Pyruvic acid, mg. %.....	0.60	..	..	..	..	..	..	..	0.62	..	..	..	..
3	Blood pressure.....	105	81	110	65	..	78	65	50-10	0	3 hr. and 30 min.	11.9	283.5	2.37
	Hematocrit reading.....	53	..	55	..	..	..	58	..	63	..	..	..	..
	Specific gravity.....	1.0218	..	1.0211	..	..	..	1.0210	..	1.0235	..	..	..	..
	Rectal temperature.....	103.5	..	103	..	..	..	103	..	102	..	..	..	..
	Pyruvic acid, mg. %.....	0.10	..	..	..	..	..	..	..	0.15	..	..	..	..
4	Blood pressure.....	110	80	70	55	..	10	..	..	0	2 hr. and 45 min.	11.1	220.3	1.93
	Hematocrit reading.....	40	..	43	..	..	..	..	..	45	..	..	..	..
	Specific gravity.....	1.0255	..	1.0218	..	..	..	..	..	1.0211	..	..	..	..
	Rectal temperature.....	103.8	..	101	..	..	..	..	..	101	..	..	..	..
	Pyruvic acid, mg. %.....	0.25	..	..	..	..	..	..	..	0.275	..	..	..	..
5	Blood pressure.....	130	80	75	68	..	40	..	..	0	2 hr. and 20 min.	11.1	453.0	3.97
	Hematocrit reading.....	63	..	61	..	..	65	..	..	67	..	..	..	..
	Specific gravity.....	1.0257	..	1.0218	..	..	1.0270	..	..	1.0271	..	..	..	..
	Rectal temperature.....	101	..	101	..	..	101.2	..	..	101.2	..	..	..	..
	Pyruvic acid, mg. %.....	0.40	..	..	..	..	..	..	..	0.13	..	..	..	..
6	Blood pressure.....	95	70	50	35	..	30	..	..	0	2 hr. and 10 min.	11.9	220.8	1.90
	Hematocrit reading.....	51	..	55	..	..	..	..	..	58	..	..	..	..
	Specific gravity.....	1.0201	..	1.0281	..	..	..	..	..	1.0280	..	..	..	..
	Rectal temperature.....	102.4	..	102.0	..	..	..	..	..	103	..	..	..	..
	Pyruvic acid, mg. %.....	0.55	..	..	..	..	..	..	..	0.57	..	..	..	..
7	Blood pressure.....	130	96	90	80-50	..	..	..	..	0	1 hr. and 50 min.	13.7	255.1	1.85
	Hematocrit reading.....	57	..	75	..	..	..	..	..	78	..	..	..	..
	Specific gravity.....	1.0251	..	1.0275	..	..	..	..	..	1.0217	..	..	..	..
	Rectal temperature.....	103	..	102.2	..	..	103	..	..	103.6	..	..	..	..
	Pyruvic acid, mg. %.....	0.215	..	..	..	..	..	..	..	0.275	..	..	..	..
8	Blood pressure.....	128	59	45	40	..	40	25	..	0	2 hr. and 45 min.	10	283.5	1.77
	Hematocrit reading.....	51	..	..	..	..	..	..	..	..	..	..	..	..
	Specific gravity.....	1.0218	..	1.0251	..	..	..	1.0223	..	..	..	..	..	..
	Rectal temperature.....	101.3	101.3	101.5	1.0211	..	..	..	..	101.5	..	..	..	..
	Pyruvic acid, mg. %.....	0.25	..	..	..	..	..	..	..	0.35	..	..	..	..
9	Blood pressure.....	90	75	60	45	..	25	..	..	0	2 hr. and 33 min.	12.8	283.5	2.21
	Hematocrit reading.....	60	..	63	..	..	..	..	..	61	..	..	..	..
	Specific gravity.....	1.0223	..	1.0230	..	..	1.0228	..	..	1.0228	..	..	..	..
	Rectal temperature.....	101	101	101.2	101.8	..	..	..	..	101.8	..	..	..	..
	Pyruvic acid, mg. %.....	0.13	..	..	..	..	..	..	..	0.30	..	..	..	..
10	Blood pressure.....	110	100	85	..	..	80	65	38-20	0	3 hr. and 35 min.	11.5	212.0	1.46
	Hematocrit reading.....	47	..	40	..	..	48	..	48	49	..	..	..	..
	Specific gravity.....	1.0210	..	1.0238	..	..	1.0235	..	1.0233	1.0215	..	..	..	..
	Rectal temperature.....	103.6	..	103.2	..	..	103.2	..	102.6	102.5	..	..	..	..
	Pyruvic acid, mg. %.....	0.15	..	..	..	..	..	..	..	0.21	..	..	..	..
Average											2 hr. and 31 min.	12.9	267.8	2.1

\* These experiments were conducted at room temperature. The tourniquet was left in place at least nine hours so that the outcome would be consistently fatal following release of tourniquet.

cross-matching tests) over a two hour period, while 200 cc. of blood was withdrawn to eliminate any deleterious effect from the large amount injected. The pulse gradually increased in rate and became weaker; the animal died five hours later. The observations at necropsy were similar to those in dogs which had died after release of the tourniquet. To the 300 cc. of cells which remained, 200 cc. of isotonic solution of sodium chloride was added, and this mixture was rapidly given to a third dog after 500 cc. of blood was withdrawn through an intra-arterial puncture of the femoral artery. This dog did not go into shock but it remained perfectly well; this indicated that there was no hypotensive factor in the cellular fraction.

EXPERIMENT 3.—Section of the spinal cord at the lowest thoracic vertebra was performed on 2 dogs of about equal weight. One dog was given 5 mg. of heparin per kilogram (to prevent thrombosis of the veins of the leg while it was being constricted), and a tourniquet was placed around the hindlimb for sixteen hours. At the end of this period a cannula was inserted in the femoral vein of the dog with the tourniquet and in the femoral vein of the control animal. By means of a three way stopcock blood was withdrawn from the ischemic leg (after the tourniquet had been released) and injected into the control dog. An equal amount of blood was removed from the control dog and injected into the dog to which the tourniquet had been applied. A cross-matching test, performed previously, had revealed that the blood of the 2 animals was compatible.

The amount of blood exchanged over a period of two hours and fifty-two minutes was 280 cc. After that time the dog to which the tourniquet had been applied died. The control dog died one hour and thirty-five minutes later.

EXPERIMENT 4.—The spinal cord of a male dog weighing 8.6 Kg. was cut at the lowest dorsal vertebra, and after allowance of four days for recovery of the animal a tourniquet was applied at the base of a hindlimb. Five milligrams of heparin per kilogram was given to minimize thrombosis of the veins in the limb. Sixteen hours later the dog was given 5 mg. of heparin and 3 mg. ( $\frac{1}{8}$  grain) of morphine per kilogram and cannulas were placed in the femoral vein above the tourniquet as well as in the femoral vein of the normal limb. Another dog (normal), which weighed 6 Kg., was given 5 mg. of heparin and 5 mg. ( $\frac{1}{2}$  grain) of morphine per kilogram; with the animal under procaine hydrochloride anesthesia a cannula was put into the femoral artery on one side and into the vein on the other. The tourniquet was then released from the other dog, and cross transfusion, with a syringe was begun immediately, at a rate of 175 cc. of blood per hour. The dog to which the tourniquet had been applied died two hours and twenty minutes after the tourniquet was released; a total of 410 cc. of blood had been transfused into each dog. After death the hindlimbs and the pelvis were resected and the pelvis split exactly in the midline, after a method described by Blalock<sup>20</sup> for determining the gain in weight in an extremity following trauma. The gain in weight in the constricted limb was only 60 Gm. which represented only 0.7 per cent of the

total body weight, an amount entirely too small to explain death from the standpoint of loss of plasma.

Thirty minutes after the transfusion was begun the pulse rate of the control dog, which was 35 before the transfusion was started, rose to 72 and became irregular. At the end of one hour it was 36 and regular; it remained normal or nearly so for the next few hours. However, the animal died twelve hours after the cross transfusion was begun. Autopsy revealed shrinkage of the spleen, pallor of the mucous membrane and hemorrhagic congestion of the mucous membranes of the intestine. Cross-matching tests had previously revealed that the blood of the 2 animals was compatible.

EXPERIMENT 5.—The spinal cord of a 13 Kg. dog was cut at the lowest dorsal vertebra, and after three days for recovery a tourniquet was applied at the base of a hindlimb. Five milligrams of heparin per kilogram was given to minimize thrombosis of the veins in the limb. Sixteen hours later the dog was given 4.6 mg. ( $\frac{1}{3}$  grain) of morphine and 5 mg. of heparin per kilogram, and cannulas were placed in the femoral vein above the tourniquet as well as in the femoral vein of the normal limb. Another dog (normal), weighing 6 Kg., was given 5 mg. of heparin and 5 mg. ( $\frac{1}{2}$  grain) of morphine per kilogram of body weight; with the animal under procaine hydrochloride anesthesia cannulas were put into the femoral artery on one side and into the vein on the other. The blood pressure and the pulse rate of the dog which had been subjected to application of the tourniquet were 120 and 44 respectively; of the control dog, 120 and 42. Cross transfusion was not begun for ten minutes. Almost immediately after release of the tourniquet the pulse rate of the shocked dog increased; it was 88 per minute eight minutes after release. Blood was slowly withdrawn at the same rate from each dog (beginning ten minutes after release of the tourniquet) and transfused into the other. The amount of blood transfused from each dog into the other was about 130 cc. per hour (by syringe). The clotting time for each dog remained slightly over thirty minutes; hence there were no difficulties from clots.

After two hours the shocked dog had a blood pressure of 60 and a pulse rate of 110; at three hours the blood pressure was 28 and the pulse rate 155. It died four hours and ten minutes after release of the tourniquet; a total of 588 cc. of blood was transfused into each dog. After two and one-half hours the blood pressure of the control dog was 100 and the pulse rate 90; after four hours they were 105 and 85 respectively. This dog became pale and lethargic and appeared in shock, although its pulse was always full. It began improving almost immediately after cessation of the transfusion and by the next morning was completely recovered.

#### COMMENT

*Method of Producing Shock.*—Next to hypotension, hemoconcentration has been considered by some investigators to be the most important sign of shock. If hemoconcentration means loss of circulating fluid, then, according to the theory of local loss of circulating fluid as the primary cause of shock, the degree of hemoconcentration, barring such variations as individual susceptibility, should be a direct indication of the severity of shock. This is not true, as the sign itself is not present in all cases of

20. Blalock, A.: Experimental Shock: The Cause of the Low Blood Pressure Produced by Muscle Injury, Arch. Surg. 20:959 (June) 1930; Experimental Shock, South. M. J. 23:1013, 1930.

shock and hematocrit readings fully as high as those which occur with the severest form of shock can be obtained with such procedures as intraperitoneal injection of dextrose without leading to a fatal issue.<sup>21</sup> This would indicate the presence of another factor in the causation of certain types of shock, although it is obvious that frequently, indeed, loss of plasma alone is sufficient to cause death. Death from tourniquet shock could be explained on the basis of a widely distributed toxin arising from the ischemic limb and acting on the vital organs, with lethal results. Blalock<sup>19</sup> has already shown that the lymph draining from a crushed limb (experimental observation) is toxic. The similarity between the pathologic systemic effects of a crushed limb and an ischemic limb is apparent but by no means absolute.

After the report of Govier and Greer<sup>22</sup> on the prolongation of survival time by administration of thiamine hydrochloride to dogs shocked by repeated hemorrhages, it might appear that a pyruvic acid compound which Peters and Peters and Long<sup>23</sup> have shown is an especially important carbohydrate catabolite of nerve tissue would be important in the pathogenesis of shock itself; hence the reason for determining the pyruvic acid blood levels periodically during the course of shock. However, no significant alteration in the pyruvic acid content of the blood was noted.

In a few preliminary studies in which the tourniquet was left in place for less than nine hours some of the dogs recovered. The constriction was thereafter always maintained for longer than nine hours. Wilson and Roome<sup>5</sup> obtained death in 100 per cent of their animals after constriction for more than six hours; Swingle and associates<sup>21</sup> reported that 96 per cent of their animals subjected to constriction for five hours died in shock. These investigators used a slightly different method of keeping the tourniquet in place, but all of them

employed anesthesia produced with barbiturate compounds for long periods of time. Fat seemed to survive longer after release of tourniquet than dogs of average weight. The length of time over nine hours that the tourniquet remained in place did not seem to bear relationship to the rapidity with which shock and death resulted after release of the tourniquet. The survival time following release of tourniquet averaged two hours and thirty-five minutes and varied between two and four hours. Seldom did thrombosis of the vessels of the limb occur, though they were constricted for as long as nine to twenty-four hours.

It is difficult to correlate the results of our experiments (i. e., production of tourniquet shock in animals which had preliminary section of the spinal cord for anesthesia) with the results of experiments of Freedman and Kabat<sup>1</sup> who traumatized the hindlegs of cats to produce shock and came to the conclusion that shock was effectively prevented in such experiments by preliminary section of the spinal cord at the level of the uppermost lumbar vertebra. In our experiments release of the tourniquet after it had been in place for nine hours or more invariably resulted in death, even though our animals had had preliminary section of the cord. The only explanation would be that there is possible a greater difference in the pathogenesis of the two types of shock (i. e. tourniquet and crush) than is supposed.

The statement of Allen,<sup>1</sup> that the most intensive and rapidly fatal shock (produced by the tourniquet method) is accompanied by the least local exudation, has been corroborated by others. In the present series of animals the increase in weight of the ischemic extremity after death (resulting from release of the tourniquet), as determined by the method (described by Blalock<sup>20</sup>) of sectioning the body through the lower part of the back and comparing the weights of the two sides, was 2.1 per cent of the body weight.

From the reports of others on the amount of loss of plasma required to produce death in animals, it is obvious that the loss, amounting to 2.1 per cent of the body weight, into the ischemic extremity in our experiments is insufficient in itself to cause death. For example, in some experiments dealing with the amount of loss of blood required to produce death, Johnson and Blalock<sup>24</sup> found that "the average loss of fluid that produced death, expressed in per-

21. Swingle, W. W.; Remington, J. W.; Kleinberg, W.; Drill, V. A., and Eversole, W. J.: An Experimental Study of the Tourniquet as a Method for Inducing Circulatory Failure in Dogs, *Am. J. Physiol.* **138**: 156, 1942.

22. Govier, W. M., and Greer, C. M.: Studies on Shock Induced by Hemorrhage: I. Effect of Thiamin on Survival Time, *J. Pharmacol. & Exper. Therap.* **72**:317, 1941; II. Effect of Thiamin on Disturbances of Carbohydrate Metabolism, *ibid.* **72**:321, 1941; III. The Correlation of Plasma Thiamin Content with Resistance to Shock in Dogs, *ibid.* **77**:40, 1943.

23. Peters, R. A.: The Biochemical Lesion in Vitamin B<sub>1</sub> Deficiency: Application of Modern Biochemical Analysis in Its Diagnosis, *Lancet* **1**:1161, 1936. Long, C., and Peters, R. A.: Pyruvate Oxidation in Brain: Evidence Derived from Metabolism of  $\alpha$ -ketobutyric Acid, *Biochem. J.* **33**:759, 1939.

24. Johnson, G. S., and Blalock, A.: Experimental Shock: IX. A Study of Effects of the Loss of Whole Blood, of Blood Plasma and of Red Blood Cells, *Arch. Surg.* **22**:626 (April) 1931.

centages of body weight, was 3.2 per cent plasma and 0.85 per cent whole blood or a total of 4.05 per cent." In their experiments the average interval between the first bleeding and death was six hours and thirty-four minutes.

Since we found that in shock produced by ischemia of the hindlimb the nervous factor did not play a primary role and that in most cases the local loss of circulating fluid was also insufficient to explain shock and death, the next most plausible explanation appeared to be toxemia.

*Role of Toxins in Production of Tourniquet Shock, as Revealed by Cross Transfusion.*—After a review of the literature on this phase of the work, experiments were designed to test this hypothesis. Much work has been done along this line, but apparently valid criticisms can be brought against much of it. It is not our purpose here to review the literature, which has been reviewed well by others (Moon,<sup>2</sup> Blalock,<sup>3</sup> Wiggers,<sup>25</sup> Scudder<sup>10</sup>); we intend only to comment on a few experiments which have a direct bearing on our own. Ebbecke<sup>26</sup> showed that cytoplasmic substance, released from cells as a result either of functional activity or of any kind of irritation to the cells, causes dilatation of adjacent capillaries; moreover, the response of endothelium to cytoplasmic substance, to metabolic substance and to metabolic products is like that resulting from lack of oxygen. Green and associates<sup>9</sup> have isolated a substance in normal muscle which produces shock and death in small animals. Griffith<sup>27</sup> has obtained a toxic substance from lymph collected from a burned area, and, as stated previously, Blalock<sup>19</sup> has recently found a substance in the lymph of the thoracic duct of dogs with traumatized hindlimbs which is capable of causing death when injected into a normal dog. Dragstedt and Mead,<sup>28</sup> Kendrick, Essex and Helmholz,<sup>29</sup> Best and Solandt<sup>30</sup> and Coonse and associates<sup>31</sup> have all obtained substances with hypotensive

properties from injured or ischemic tissues.<sup>32</sup> However, Wilson and Roome<sup>5</sup> concluded that extracts from traumatized limbs cause a rise in blood pressure. Numerous investigators have tested the toxicity of blood returning from traumatized and ischemic areas, but few or none have offered proof of the existence of a lethal toxin. True enough, in most instances the amount of blood injected into the normal animal has been insufficient.

Bell, Clark and Cuthbertson<sup>33</sup> performed 6 experiments on cross circulation in dogs in which they connected the femoral vein of a traumatized limb to that of a recipient. Death occurred in seventy-five minutes in the donor, and then the recipients were destroyed. The sixth recipient was not destroyed but lived ten and one-half hours. They stated that the dog died from edema of the lungs.

Owing to certain circumstances we were unable to complete the series of experiments on cross circulation; only 5 were performed. However, in these preliminary experiments evidence accumulated to lead us to the belief that blood returning from an extremity subjected to application of a tourniquet for from nine to sixteen hours is toxic to other dogs. Although all experiments were designed to test the venous blood from the constricted limb for toxins, certain variations were adopted to rule out as much as possible error from coincidence. However, all 5 experiments were conducted so that the blood transfused from the dog to which the tourniquet had been applied to the control animal came from the femoral vein draining blood from the extremity after release of the tourniquet. In 4 of the 5 animals transfusion was begun immediately after release of the tourniquet, so that none of the blood draining through the femoral vein escaped into the circulation of the shocked dog after release of the tourniquet. All 4 of the control dogs receiving blood collected from the femoral vein of the constricted limb died of shock identical to the type which killed the dog to which the tourniquet had been applied. The duration of life varied from two hours and twenty minutes to twelve hours. In the fifth

25. Wiggers, C. J.: The Present Status of the Shock Problem, *Physiol. Rev.* **22**:74, 1942.

26. Ebbecke, cited by Moon.<sup>2</sup>

27. Griffith: Unpublished data; personal communication to Blalock.

28. Dragstedt, C. A., and Mead, F. B.: A Pharmacologic Study of the Toxemia Theory of Surgical Shock, *J. A. M. A.* **108**:95 (Jan. 9) 1937.

29. Kendrick, D. B.; Essex, H. E., and Helmholz, H. F.: An Investigation of Traumatic Shock Bearing on the Toxemia Theory, *Surgery* **7**:753, 1935.

30. Best, C. H., and Solandt, D. Y.: Studies in Experimental Shock, *Canad. M. A. J.* **43**:206, 1940.

31. Coonse, G. K.; Foissie, P. S.; Robertson, H. F.; and Aufranc, O. E.: Traumatic and Hemorrhagic Shock: Experimental and Clinical Study, *New England J. Med.* **212**:647, 1935.

32. Since this article was prepared for publication, Prinzmetal, Freed and Kruger (Pathogenesis and Treatment of Shock, *War Med.* **5**:74 [Feb.] 1944) have demonstrated development and fatal absorption of a toxin arising from bacterial action in crushed muscle (in dogs). Also Aub and others (Bacteria and the "Toxic Factor" in Shock, *ibid.* **5**:71 [Feb.] 1944) reported demonstration of a shock-producing toxin, likewise of bacterial origin, in anoxic muscle, the blood supply of which was occluded by rubber bands.

33. Bell, J. R.; Clark, A. M., and Cuthbertson, D. P.: Experimental Traumatic Shock, *J. Physiol.* **92**:361, 1938.

experiment blood from the ischemic limb was allowed to flow into the general circulation for ten minutes before any was removed for transfusion into the control dog. In this experiment the control animal went into shock but improved after the transfusion was terminated, and it was alive the next morning. Although no conclusion can be deduced from 1 experiment, survival of this animal might be attributed to the fact that it did not receive the blood draining from the constricted limb immediately after release of the tourniquet. If a toxin is present at all in the limb to which a tourniquet is applied, it theoretically should be more concentrated in the first blood drained from the extremity just after release of the tourniquet.

It is obvious that if a toxin is present in the ischemic, or anoxic, limb it would be much more concentrated in the blood of the femoral vein draining from the limbs than in the systemic blood collected elsewhere. It was for this reason that blood from the shocked dog was collected from this source.

The limb subjected to the application of the tourniquet (nine to sixteen hours) was the seat of a variable amount of edema (even before release of the tourniquet), as has been observed by others, which presumably is caused by blood escaping into the limb through the femur (Blacklock). After release of the tourniquet there was a surprisingly slight increase in the amount of edema, as determined by measurement; the exact amount would be difficult to measure in the individual limbs. Unquestionably, the level of application of the tourniquet would be directly related to the percentage of loss of fluid into the extremity. In general, the percentage of gain as compared with the total body weight would be increased if the level of application of the tourniquet was located farther toward the trunk, and vice versa. As stated previously, the total weight lost into the constricted limb in our experiments was only 2.1 per cent of the body weight, an amount definitely too small to explain death on the basis of loss of plasma or blood alone. The loss of plasma in our experiments is less than in the experiments of at least some other observers, probably because we applied the tourniquet at a slightly lower level. Since the studies on weight in the 10 experiments described in the table indicated loss of plasma as inadequate to explain death, comparative weights of the limbs of the 5 dogs used in the experiments on cross transfusion were determined on only one occasion. At this time the gain of weight in the ischemic limb, as determined by comparative weights after death, was only 0.7 per cent of the total body weight,

or much less than the average in the animals subjected to cross transfusion. A discrepancy in this direction might be expected in animals subjected to cross transfusion, since the effort to aspirate the maximum amount of blood (syringe) from the vein might tend to decrease the amount of plasma stagnating in the limb.

Theoretically, if blood flowing through the collateral veins (as well as the femoral vein) from the constricted limb were prevented from entering the general circulation, death could be postponed for days (until infection developed). In the 5 experiments described, no attempt was made to block the collateral veins. Removal of blood from the femoral vein might minimize development of any possible toxic action of the animal, and therefore life would be prolonged longer than in animals in which blood from all veins in the limb to which the tourniquet had been applied was allowed to enter the general circulation. The average duration of life following release of the tourniquet in animals in which blood from the femoral vein was diverted for transfusion into another dog was only five or ten minutes longer than that in animals in which no blood was removed after release of the tourniquet. It appears likely that heparin, which was administered to the 5 dogs subjected to cross transfusion (to prevent clotting), might tend to shorten life, since clotting in the veins in the 10 dogs not receiving heparin would delay escape of any toxic product present. Naturally a comparison of the duration of life in animals receiving and those not receiving heparin would throw light on the question.

No effort was made to determine the source of any toxic products which may have developed in the constricted limb. They presumably might be catabolic or bacterial in origin. The fact that half of the control animals receiving blood from the ischemic limb lived only two or three hours suggests that bacterial action was not probable, although it might be possible for bacteria to grow and produce toxins in the limbs to which the tourniquet had been applied for nine to sixteen hours.

#### SUMMARY

Tourniquet shock can be produced consistently in animals and is therefore particularly adaptable for study, but the extreme pain produced by the tourniquet makes it necessary to utilize some type of anesthesia. Prolonged anesthesia, whether produced by a barbitol compound or a general anesthetic, is undesirable. Moreover, since nervous impulses are obviously so intensive, this factor might alter the data

derived from the experiment. To obviate these disadvantages we have adopted the procedure of cutting the spinal cord at the level of the lowest dorsal or the uppermost lumbar vertebra, two to four days before the experiment is to be performed. It is unwise to wait much longer, since the anesthesia induced in the lower extremities, which are dragged over the floor of the cage, may allow development of ulcers, infection, etc. Manipulation or operation may be conducted without pain on the lower extremities of the animal with no more anesthetic than a moderate dose of morphine. To keep the tourniquet anchored in one place a sterile nail can be driven deeply into the trochanter. In the experiments in which shock was produced by release of the tourniquet death always occurred if the tourniquet was left in place for at least nine hours. In 10 animals studied by this method, death occurred after an average of two hours and thirty-four minutes following release of the tourniquet. The average loss of plasma into the extremity before and following release of the tourniquet, as determined by the method of Blalock, was only 2.1 per cent of the total body weight, which is insufficient in itself to explain death.

To determine whether or not a toxin may have developed in the constricted limb and may have

been an important factor in the pathogenesis of shock and death, we performed cross transfusion, injecting blood obtained from the distal portion of the femoral vein of the constricted limb into a normal (control) animal. To prevent increase in shock in the animal subjected to the application of the tourniquet through loss of blood, an equal amount of blood was removed from the recipient (control) dog and injected into the shocked animal.

Because of exigencies of war, work on the problem was interrupted; only 5 such experiments could be performed. Four of the 5 animals receiving blood from the constricted limb after release of the tourniquet died two to twelve hours after the transfusion was begun. The only dog to survive transfusion of blood which had circulated through the constricted limb was 1 which did not receive any blood from the constricted limb until ten minutes following release of the tourniquet. If a toxin were present in the constricted limb it would supposedly be more concentrated in the blood draining from the limb during the first few minutes following release of the tourniquet. If this were true, survival of this animal, which, however, did go into shock during the transfusion (but recovered afterward), might be explained.



# MECKEL'S DIVERTICULUM

DYSPEPSIA MECKELI FROM HETEROTOPIC GASTRIC MUCOSA

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## DEFINITION

The vitellointestinal duct is a communication between the midgut and the yolk sac of the embryo during the first few weeks of fetal life (fig. 1). Persistence of this duct or of portions of it gives rise to a deformity known as Meckel's diverticulum,<sup>1</sup> so called after J. F. Meckel, who was the first to publish an adequate description of the anomaly, in 1812,<sup>2</sup> though he had mentioned it in an earlier publication, in 1809.<sup>3</sup> According to Lichtenstein,<sup>4</sup> the diverticulum was mentioned by Hildanus in 1598. Lavater<sup>5</sup> mentioned it in 1671.<sup>6</sup> It was described by Littré in 1700 as being present in a hernia (Strohl and McArthur<sup>7</sup>). In the adult, Meckel's diverticulum usually rises from the antemesenteric portion of the ileum about 20 inches (50 cm.) proximal to the ileocecal valve, the distance being less directly as the age approaches infancy. However, it may be found at any point along the intestinal tract. In a like manner, it may vary greatly in length, from a fraction of an inch to as long as 2 feet (60 cm.). Some type of Meckel's anomaly is present in approximately 4 per cent of all newborn infants (Ladd<sup>1</sup>), though the rate of occurrence in adults is given as from 1 per cent to 3 per cent by different authorities (Curd,<sup>7</sup> Everhart<sup>8</sup> and Waugh and others<sup>9</sup>).

## PATHOLOGY

Meckel's diverticulum may be present throughout the life of a person and yet cause no symptoms, but owing to the serious consequences of the pathologic conditions to which it is subject it is always a source of great potential danger. It has been estimated that from 15 to 20 per cent of the diverticula are subject to pathologic changes which cause symptoms (Faust<sup>10</sup>). In other words, for every 2 diverticula found diseased there are 8 with no symptoms.

Before discussing the pathology of Meckel's diverticulum, it will be well to mention the various anatomic types that can occur. The anatomic descriptions which follow are drawn mainly from those of Callander<sup>11</sup> and Nygaard and Walters<sup>12</sup> (fig. 2 and 3). 1. The vitellointestinal duct may remain open, with the result that a fistula persists between the ileum and the skin of the umbilicus. 2. The vitellointestinal duct may be partially obliterated so that mucous membrane is present at the distal end at the umbilicus, whereas at its attachment to the ileum it has become a solid cord; it may be partially obliterated in its distal portion and opened at its attachment to the bowel, thus forming a diverticulum which is attached by a solid cord to the umbilicus; a diverticulum may be present with the obliterated cord attached to some point within the abdominal cavity; or a diverticulum from the bowel may be connected to persistent mucous membrane at the umbilicus by a cord of obliterated duct. 3. The duct may be completely obliterated with a cord remaining: (a) attached to the umbilicus, (b) hanging free in the abdominal cavity or (c) attached to some point within the

9. Waugh, J. M.; Herrell, W. D., and Crumacker, L. K.: Peptic Ulcer in Meckel's Diverticulum Causing Intrinsic Intestinal Obstruction, *Surgery* **11**:385-391 (March) 1942.

10. Faust, L. S.: Meckel's Diverticulum with Unusual Clinical Manifestations, *M. Clin. North America* **15**:1483-1489 (May) 1932.

11. Callander, C. L.: *Surgical Anatomy*, ed. 3, Philadelphia, W. B. Saunders Company, 1936.

12. Nygaard, K. K., and Walters, W.: Malignant Tumors of Meckel's Diverticulum, *Arch. Surg.* **35**:1159-1172 (Dec.) 1937.

1. Ladd, W. E.: Meckel's Diverticulum, in Christopher, F.: *Textbook of Surgery*, ed. 3, Philadelphia, W. B. Saunders Company, 1942, pp. 1163-1164.

2. Meckel, J. F.: *Handbuch der pathologischen Anatomie*, Leipzig, C. H. Reclam, 1812, vol. 1, pp. 533-557.

3. Meckel, J. F.: Ueber die Divertikel am Darmkanal, *Arch. f. d. Physiol.* **9**:421-453, 1809.

4. Lichtenstein, M. E.: Meckel's Diverticulum, *Quart. Bull., Northwestern Univ. M. School* **15**:296-300, 1941.

5. Lavater, J. H.: *De enteropneuriā seu intestinorum compressione*, Basilae, typ. J. Bertschi, 1672.

6. Strohl, E. L., and McArthur, S. W.: Incarcerated Meckel's Diverticulum in Femoral Hernia, *Arch. Surg.* **38**:783-787 (April) 1939.

7. Curd, H. H.: Histologic Study of Meckel's Diverticulum, *Arch. Surg.* **32**:506-523 (March) 1936.

8. Everhart, M. W.: Complications of Meckel's Diverticulum in Infancy and Childhood, *J. Pediat.* **17**:483-489 (Oct.) 1940.

abdominal cavity. 4. The duct may contain a cyst (*a*) in its central portion or (*b*) in its distal portion with a sinus opening in the umbilicus. 5. The duct may end in a blind pouch in the form of a pseudodiverticulum hanging free in the abdominal cavity, which is the usual anatomic condition found. 6. It may end in a simple blind pouch, and instead of hanging free in the

from the umbilicus (Rentschler<sup>13</sup>). The discharge from such a fistula is extremely irritating and if the defect is not repaired the discharge may lead to digestion of the skin of the abdominal wall. There may be an omphalocele (Morrison and Neville<sup>14</sup>). 2. Intestinal obstruction results from rotation of the bowel on the long axis of the diverticulum or from coils of adjacent bowel

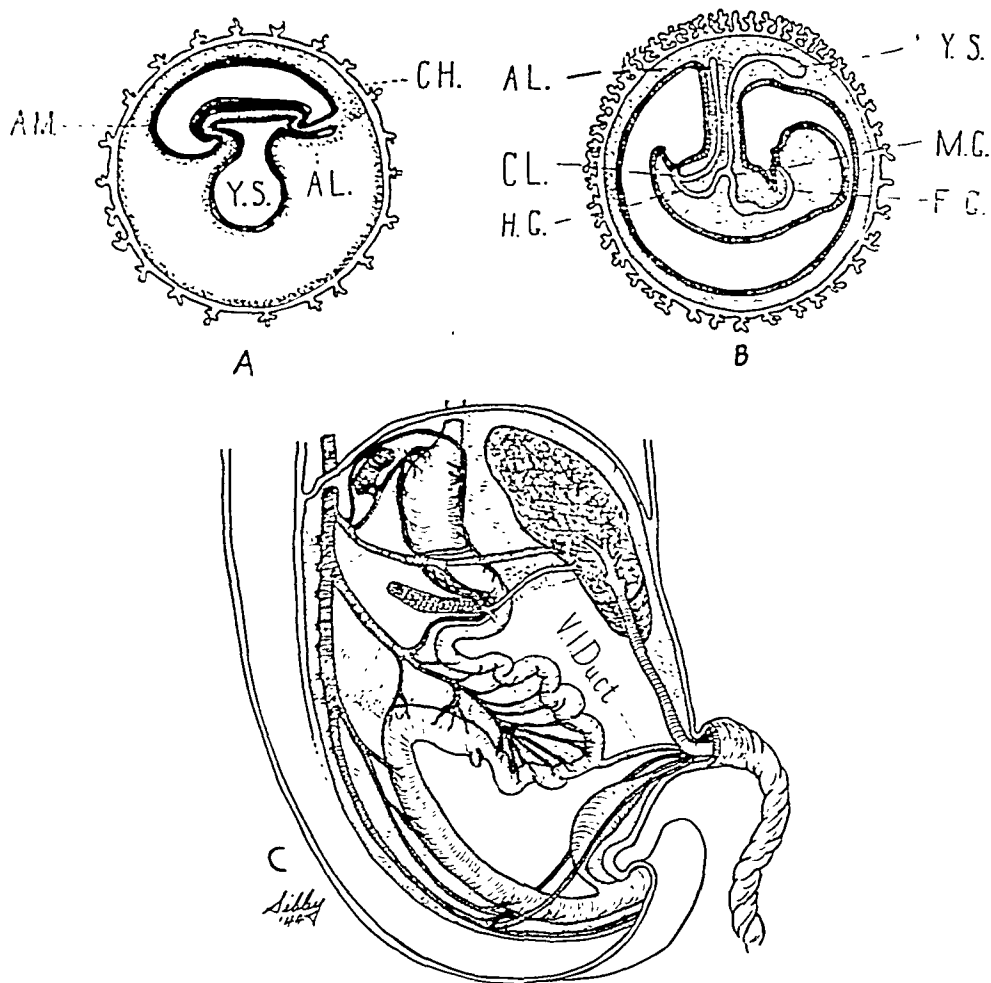


Fig. 1.—*A* and *B*, diagrams illustrating the formation of the vitellointestinal duct. In *A* there is a wide communication between the yolk sac and the midgut, so that it is virtually one large cavity. The allantois is present at this stage. In *B* the vitellointestinal duct has formed between the midgut and the yolk sac. *AL.* indicates allantois; *AM.*, amnion; *CH.*, chorion; *CL.*, cloaca; *F.G.*, foregut; *H.G.*, hindgut; *M.G.*, midgut; *Y.S.*, yolk sac. (Redrawn from Morris' *Human Anatomy*, edited by C. M. Jackson, ed. 9, Philadelphia, 1933, P. Blakiston's Son & Co.). *C*, diagram illustrating the relationship of the vitellointestinal duct to the intestinal tract and to the umbilicus. Meckel's diverticulum is formed by the persistence of this duct or parts of it. (Redrawn from Callander.<sup>11</sup>)

abdominal cavity, it may be buried within the substance of the mesentery. 7. The diverticulum may have its own mesenteriolum. 8. There may be diverticulosis of Meckel's diverticulum.

The pathologic changes accompanying Meckel's diverticulum depend to a large extent on the anatomic deformities present. 1. If a fistula persists, intestinal contents drain to the abdomen

becoming looped around the diverticulum when it is attached to the abdominal wall or to some point within the abdominal cavity. 3. The cystic

13. Rentschler, C. B.: Persistence of Meckel's Diverticulum, *Arch. Surg.* 40:694-695 (April) 1940.

14. Morrison, H. J., and Neville, R. L.: Omphalocele with Congenital Obstruction, *Am. J. Dis. Child.* 65:781-784 (May) 1943.

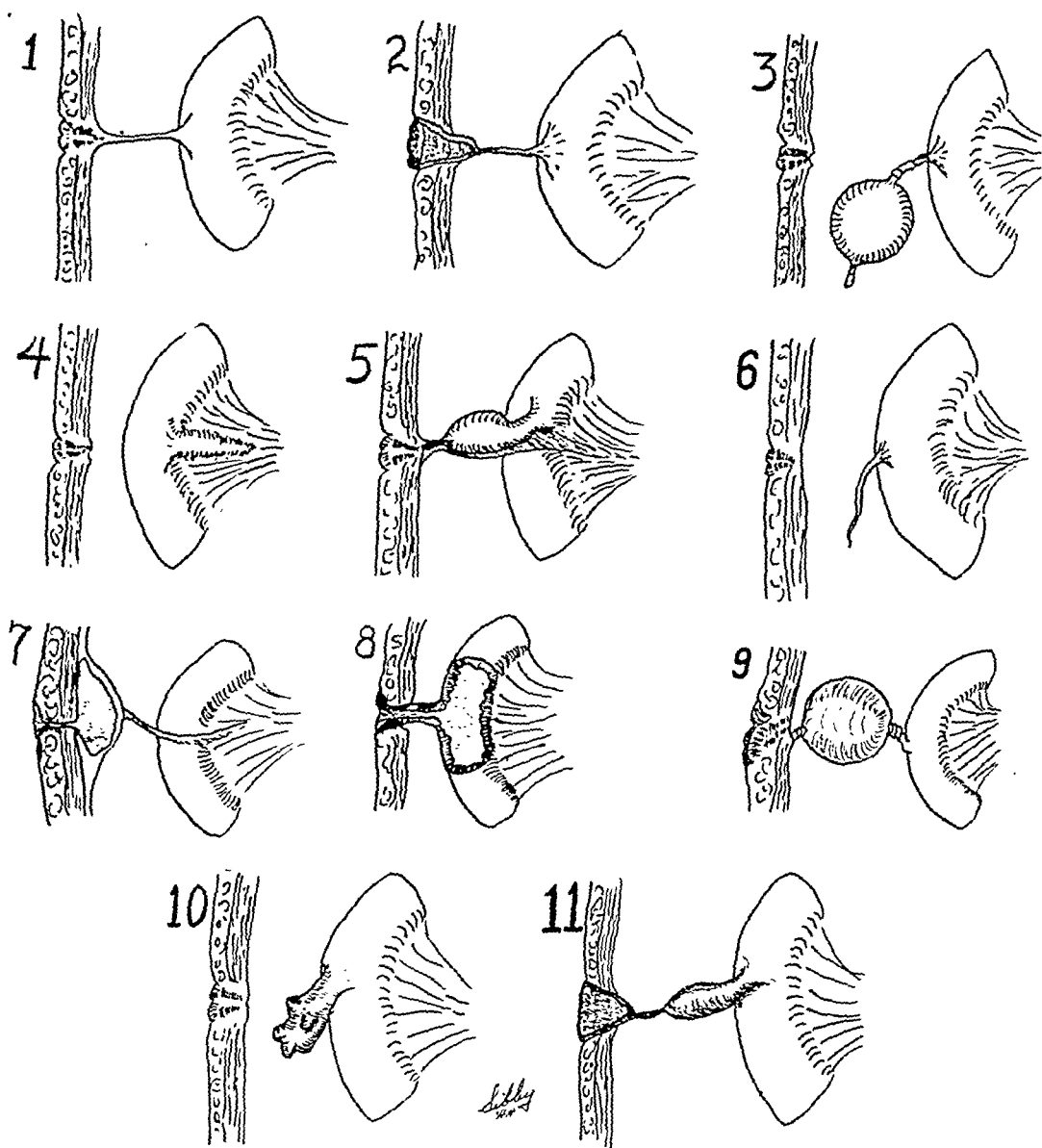


Fig. 2.—Diagrams illustrating some of the various anatomic types of Meckel's diverticulum: 1, fibrous cord attached to the umbilicus from the ileum; 2, persistent mucosa at the umbilicus attached to the ileum by a fibrous cord; 3, cyst hanging from the ileum by a twisted fibrous cord; 4, blind, tubular sac beneath the serosa of the mesentery of the ileum; 5, blind, tubular diverticulum attached to the umbilicus by a fibrous cord, having its own mesenteriolum; 6, fibrous cord, remnant of the vitellointestinal duct, hanging free from the ileum (the cord may be attached to the adjacent bowel); 7, cyst draining through the umbilicus, attached to the ileum by a fibrous cord; 8, persistent, patent vitellointestinal duct, lined with mucosa, draining to the umbilicus from the ileum; 9, cyst attached distally to the umbilicus and proximally to the ileum by a twisted fibrous cord; 10, saccular diverticulum of the ileum showing diverticulosis of the diverticulum; 11, saccular diverticulum of the ileum attached by a fibrous cord (obliterated vitellointestinal duct) to a saccular area of mucosa in the umbilicus (similar to the diverticulum in the case reported by Ehrenpreis<sup>15</sup>). (Diagrams 7, 8 and 9 were redrawn from Callander<sup>11</sup>; diagrams 1 to 6 inclusive, from Nygaard and Walters.<sup>12</sup>)

type is thought to result from a rotation of the bowel in early fetal life causing a spiral twist in the long axis of the vitellointestinal duct (Callander<sup>11</sup>). Sometimes the cyst is situated just beneath the umbilicus and drains to the abdomen through the umbilicus (Ehrenpreis<sup>15</sup>). 4. The vitellointestinal duct is usually obliterated and absorbed during the seventh week of intra-uterine development (Matt and Timpone<sup>16</sup>). However, it may fail to become absorbed so that a fibrous cord persists. Intestinal obstruction results from rotation of the bowel on the cord or from loops of bowel becoming twisted around the cord in a manner similar to that described in item 2. 5. Inflammation occurs in the walls of Meckel's diverticulum, just as it does in the appendix. Such inflammation is called diverticulitis. The diverticulitis may be acute and

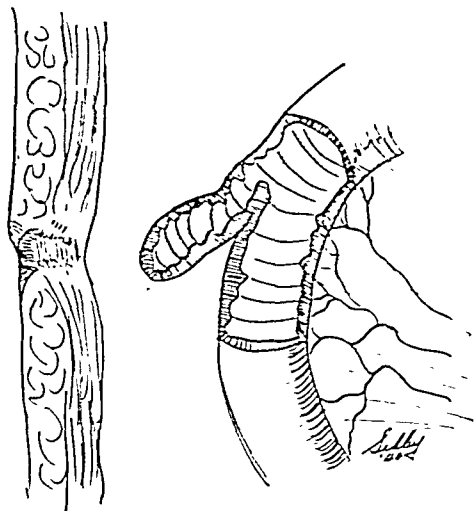


Fig. 3.—Diagram illustrating a cross section of the most common type of Meckel's diverticulum, a simple tubular, blind sac arising from the antemesenteric aspect of the ileum. (Redrawn from Callander<sup>11</sup>)

severe, or it may be chronic and mild. The inflammatory process may extend beyond the walls of the diverticulum and give rise to peritonitis. Coley<sup>17</sup> has reported a case of tuberculosis in Meckel's diverticulum. 6. Heterotopic tissues may be present in Meckel's diverticulum in the form of pancreatic, biliary, duodenal, ileal, colonic and gastric tissues (Wilson,<sup>18</sup> Salzer,<sup>19</sup> Zencker,<sup>20</sup>

Hunt,<sup>21</sup> Curd<sup>7</sup> and Greenblatt, Pund and Chaney<sup>22</sup>). Heterotopic tissues occur in approximately 25 per cent of the cases of Meckel's diverticulum (Matt and Timpone<sup>16</sup>). These tissues are thought to be present as a result of one or more conditions. Some of the theories listed by Greenblatt, Pund and Chaney<sup>22</sup> are: (a) Albrecht's theory that the entoderm of the primitive gut is composed of pluripotential cells and that some of these cells persist in the diverticulum and give rise to the various types of tissues found; (b) Farr and Penke's theory that the cells represent vestiges of a primitive digestive system which during the first few weeks of fetal life secretes digestive juices for the utilization of the contents of the yolk sac during this period; (c) the dysembryoma theory of Pierre Masson, and (d) the reimplantation theory of Shaetz. The most common type of heterotopic tissue found in Meckel's diverticulum is gastric mucosa. It has been conclusively demonstrated that this gastric mucosa is capable of secreting hydrochloric acid and pepsin just as does that in the stomach (Dragstedt<sup>23</sup> and Waugh, Herrell and Crum-packer<sup>9</sup>). It has been shown that the gastric mucosa in Meckel's diverticulum is acted on by the secretory hormone that stimulates secretion by the mucosa of the stomach, and that the secretion in the diverticulum occurs at the same time that it does in the stomach (Greenblatt, Pund and Chaney<sup>22</sup>). It has also been shown that the mucosa of the intestine becomes progressively more sensitive to the irritating properties of hydrochloric acid and pepsin as the distance from the stomach increases (Matthews and Dragstedt<sup>24</sup>). The hydrochloric acid and pepsin secreted by the gastric mucosa in Meckel's diverticulum are probably responsible for the ulcerations that sometimes occur in the diverticulum. Womack and Siegert<sup>25</sup> state that the first account of hydrochloric acid being secreted from Meckel's diverticulum was made by Till-

19. Salzer, H.: Ueber das offene Meckel'sche Divertikel, Wien. klin. Wchnschr. 17:614-617, 1904.

20. Zencker, F. A.: Virchows Arch. f. path. Anat. 21:369, 1861.

21. Hunt, V. C., and Bonesteel, H. T. S.: Meckel's Diverticulum Containing Aberrant Pancreas. Arch. Surg. 28:425-439 (March) 1934.

22. Greenblatt, R. B.; Pund, E. R., and Chaney, R. H.: Meckel's Diverticulum, Am. J. Surg. 31:285-293 (Feb.) 1936.

23. Dragstedt, L. R.: Ulcus Acidum of Meckel's Diverticulum, J. A. M. A. 101:20-22 (July 1) 1933.

24. Matthews, W. D., and Dragstedt, L. R.: Etiology of Gastric and Duodenal Ulcer: Experimental Studies, Surg., Gynec. & Obst. 55:265-286 (Sept.) 1932.

25. Womack, N. A., and Siegert, R. B.: Surgical Aspects of Lesions of Meckel's Diverticulum, Ann. Surg. 108:221-236 (Aug.) 1938.

15. Ehrenpreis, B.: Roentgenological Diagnosis of Meckel's Diverticulum, Am. J. Roentgenol. 42:280-284 (Aug.) 1939.

16. Matt, J. G., and Timpone, P. J.: Peptic Ulcer of Meckel's Diverticulum: Case Report with Review of the Literature, Am. J. Surg. 47:612-623 (March) 1940.

17. Coley, B. L.: Tuberculosis of Meckel's Diverticulum Associated with Tuberculosis of the Appendix, Arch. Surg. 11:519-528 (Oct.) 1925.

18. Wilson, H.: Meckel's Diverticulum, Am. J. Surg. 55:614-618 (June) 1942.

mans in 1882. When an ulcer has formed, there may be an associated hemorrhage from the walls of the ulcer (Waugh, Herrell and Crumpacker,<sup>9</sup> Everhart,<sup>8</sup> Weiner and Seley,<sup>26</sup> Higgons and Gundy,<sup>27</sup> and Christopher and Blessing<sup>28</sup>). However, hemorrhage also occurs from the walls of the ileum owing to the irritating effects of the acid secreted by the heterotopic tissue within the diverticulum (Higgons and Gundy,<sup>27</sup> Mason and Graham,<sup>29</sup> Cobb<sup>30</sup>). The peptic ulcer formed by the action of the acid from the heterotopic tissue may perforate and cause peritonitis. 7. Tumors occur in Meckel's diverticulum, and they may be benign or malignant (Greenblatt, Pund and Chaney,<sup>22</sup> Koucky and Beck,<sup>31</sup> Gray and Kernohan,<sup>32</sup> Weir,<sup>33</sup> Nygaard and Walters<sup>12</sup>). 8. Intussusception occurs from invagination of the diverticulum per se or from invagination due to the presence of a tumor (Harkins,<sup>34</sup> Bowen,<sup>35</sup> Gray and Kernohan<sup>32</sup>). The diverticulum may become the accidental reservoir of foreign bodies. Numerous reports of this have been made, revealing a great variety of foreign bodies, such as fish bones, pins, needles, grains of corn, cherry seeds and gallstones, and other types of concretions (Womack and Siegert,<sup>25</sup> Mulsow<sup>36</sup> and Giles and MacCarty<sup>37</sup>). Foreign bodies may

perforate the walls of the diverticulum and set up infection within the walls of the diverticulum and frequently produce peritonitis. They produce pressure erosion of the wall of the diverticulum and they may cause intestinal obstruction.

#### DYSPEPSIA MECKELI

Although any of the pathologic conditions have been listed may occur, the ones most commonly found may be grouped into three categories, namely: (1) inflammatory type; (2) peptic ulcer type with or without hemorrhage and (3) intestinal obstruction type with or without intussusception. It would appear that the other phase of the peptic ulcer type is being overlooked and not being recognized. It is the group of diverticula that contain heterotopic gastric mucosa which when examined show no evidence of inflammation or other disease. Goodman<sup>38</sup> has shown the relationship of acid to pain in the peptic ulcer of Meckel's diverticulum, and he quotes Burger<sup>39</sup> as stating that the adjacent small bowel walls of the diverticulum in such conditions are prone to spasmic contractions when gas and ulceration are present in the diverticulum. A priori, it would appear that the hydrochloric acid and pepsin secreted by the heterotopic gastric mucosa in the diverticulum cause irritations in the ileum and in the diverticulum which produce spasms in the musculature of the ileum and diverticulum. These spasms, in turn, cause the symptoms of pain even in the absence of ulcer or inflammation. This might be called dyspepsia Meckeli and probably represents a pre-ulcerative condition in the diverticulum or the marginal portion of the ileum.

#### CLASSIFICATION

Attempts have been made to classify the diseases of Meckel's diverticulum. The best classification is probably that of Greenblatt and his co-workers.<sup>22</sup> Briefly, this classification is as follows:

1. Peptic ulcer type
  - (a) Gastric mucosa without ulceration
  - (b) Gastric mucosa with ulceration
  - (c) Ulceration with hemorrhage
  - (d) Ulceration without hemorrhage
2. Obstructive type
  - (a) Intussusception
  - (b) Volvulus
  - (c) Congenital bands and adhesions
  - (d) Contents of hernia

26. Weiner, S. B., and Seley, G. P.: Bleeding Meckel's Diverticulum in Ten Months' Old Infant, *J. Mt. Sinai Hosp.* 5:620-626 (Jan.-Feb.) 1939.

27. Higgons, R. A., and Gundy, J. E.: Hemorrhage from Meckel's Diverticulum, *J. Pediat.* 11:563-567 (Oct.) 1937.

28. Christopher, F., and Blessing, R.: Perforated Ulcer of Meckel's Diverticulum, *Am. J. Surg.* 31:556-557 (March) 1936.

29. Mason, J. M., and Graham, G. S.: Ulceration of Aberrant Gastric Mucosa in Meckel's Diverticulum as Source of Intestinal Hemorrhages, *Ann. Surg.* 96:893-910 (Nov.) 1932.

30. Cobb, D. B.: Meckel's Diverticulum with Peptic Ulcer, *Ann. Surg.* 103:747-764 (May) 1936.

31. Koucky, J. D., and Beck, W. C.: Perforated Leiomyoma of Meckel's Diverticulum, *Surgery* 10:636-641, 1941.

32. Gray, H. K., and Kernohan, J. W.: Meckel's Diverticulum—Adenocarcinoma of Gastric Mucosa, *J. A. M. A.* 108:1480-1483 (May) 1937.

33. Weir, J. M.: Carcinoma of Meckel's Diverticulum, *Arch. Path.* 35:1159-1172 (Dec.) 1937.

34. Harkins, H. N.: Intussusception Due to Invaginated Meckel's Diverticulum, *Ann. Surg.* 98:1070-1095 (Dec.) 1933.

35. Bowen, F. H.: Intussusception Associated with Polyp in Meckel's Diverticulum, *J. M. A. Georgia* 30:390-391 (Sept.) 1941.

36. Mulsow, F. S.: Meckel's Diverticulum Containing Calculi, *Am. J. Digest. Dis.* 10:188-189 (May) 1943.

37. Giles, J. F., and MacCarty, W. C.: Calcified Concretions Within a Meckel's Diverticulum, *Radiology* 41:491-494 (Nov.) 1943.

38. Goodman, B. A.: Meckel's Diverticulum, *Arch. Surg.* 36:144-162 (Jan.) 1938.

39. Burger, W.: Ueber das Meckel'sche Diverticulum mit Magenschleimhaut, *Inaug. Dissert., Heidelberg.* J. Horning, 1932.

3. Diverticular type
  - (a) Simple acute inflammation
  - (b) Perforated and gangrenous
  - (c) Chronic inflammation
4. Umbilical type
  - (a) Fecal fistula
  - (b) Umbilical adenoma
  - (c) Prolapsed intestine through fistula
5. Tumor type
  - (a) Benign
    - (1) Carcinoid
    - (2) Enterocystoma
    - (3) Adenoma
    - (4) Mesodermal tumor
  - (b) Malignant
    - (1) Carcinoma
    - (2) Sarcoma
  - (c) Heterotopic
    - (1) Pancreatic
    - (2) Gastric
    - (3) Biliary
    - (4) Colonic
    - (5) Jejunal
    - (6) Duodenal, etc.
6. Incidental type
 

Normal tissue of ileum

#### SYMPTOMS

The signs and symptoms that occur from Meckel's diverticulum depend to a great degree on the anatomic disposition of the tissues and the pathologic changes involved in the diverticulum. Since these factors are extremely variable, it can be readily seen that the signs and symptoms also may be diversified. The presence of a fecal fistula or prolapsed intestine at the site of the umbilicus can be determined by inspection of the abdomen. A cyst within the abdominal cavity may be detected by palpation of the abdomen, though it may be misinterpreted as being of pancreatic origin. The cyst may cause abdominal pains of a vague description, usually localized around the umbilicus. If the cyst is draining from the umbilicus, it can be probed or iodized oil may be injected for roentgenologic diagnosis. The other signs and symptoms of disease in Meckel's diverticulum fall into three groups, namely: (1) the obstructive type, (2) the inflammatory type and (3) the peptic ulcer type. The signs and symptoms of intestinal obstruction may be mild with progression to advanced severity, or they may be severe from the beginning. If the obstruction is caused by intussusception, the signs and symptoms are the same as intussusception from any other cause. If the obstruction is due to incarceration of the diverticulum in a hernia, the signs and symptoms are those of incarcerated hernia. Intestinal obstruction from a tumor in the diverticulum is determined by operation for intestinal obstruction. The occurrence of diverticulitis may give rise to signs and symptoms which so closely

resemble those of appendicitis that it is almost impossible to distinguish the one from the other. The pain and tenderness of diverticulitis are frequently greatest in the neighborhood of the umbilicus, or just below it and to the right. Sometimes the pain is referred to the epigastrium. The signs and symptoms of the peptic ulcer type may fall into three categories: (1) pain, (2) melena and (3) age. The pain of the peptic type is likely to resemble that of duodenal ulcer, having a definite time relation to the ingestion of food. The pain is usually localized in the neighborhood of the umbilicus or in the epigastrium. The melena is usually periodic. It may be insidious or severe. The hemorrhages are usually of considerable volume, but the period of bleeding is of short duration, being characterized by the presence of fresh blood mixed with some old blood, especially in the form of small clots. Most of the patients reported to have bleeding as a symptom have been under 15 years of age. The diagnosis of hemorrhage caused by Meckel's diverticulum is usually made by exclusion, since roentgenologic, proctoscopic and laboratory studies nearly always give negative results.

In 5 of the cases reported in this paper, heterotopic gastric mucosa was found in the diverticulum. In none of the 5 cases was there any evidence of inflammation in the appendix or in the diverticulum. There was a history of rather severe abdominal pain, the white blood cell counts were slightly elevated and all the patients seemed to have appendicitis. Three of them had pain and tenderness in the area of the umbilicus and slightly below it. It is believed that these 5 cases were instances of a type of dyspepsia or of a preulcerative phase of the peptic ulcer type of syndrome.

#### TREATMENT

The treatment of Meckel's diverticulum is surgical. It must be directed toward relieving the symptoms produced by the diverticulum. If obstruction is present, it must be relieved. If intussusception is present, it must be reduced surgically. If a fistula is present, it must be closed. If the diverticulum is enclosed in a hernia sac, it must be reduced. If recurrent pains are the symptoms, they must be relieved. Furthermore, all procedures carried out for the relief of symptoms caused by Meckel's diverticulum must include excision of the diverticulum. Matt and Timpone<sup>16</sup> and Wilson<sup>18</sup> stated the belief that the gastric mucosa frequently found in Meckel's diverticulum may extend to the walls of the ileum at the base of the diverticulum; they recommended wide excision or segmental resection of the ileum containing the diverticulum with

reestablishment of continuity of the bowel. However, according to the observations of Curd<sup>7</sup> in a histologic study of Meckel's diverticulum, this wide excision would not appear to be necessary. Curd stated that the heterotopic gastric mucosa is always found in the distal part of the diverticulum. When the diverticulum is excised, closure should be made accurately in a transverse plane which is perpendicular to the long axis of the bowel. Morrison and Neville<sup>14</sup> reported a case of omphalocele in an infant 60 minutes old which they successfully closed. Rentschler<sup>12</sup> reported a case of successful closure of a fistula in a 3 month old infant. In the management of intussusception great care must be taken to exclude Meckel's diverticulum, since the presence of this condition may be masked by the intussusception. If a diverticulum is found in a hernia sac it should be replaced within the abdomen, the hernia repaired and the diverticulum excised immediately through a separate incision (Harrington<sup>40</sup>).

#### PROGNOSIS

The over-all mortality rates reported have been alarmingly high. Some of the mortality rates range from 9.3 per cent (Goodman<sup>38</sup>) to as high as 57 per cent (Everhart<sup>8</sup>). It is probable that the mortality rate can be greatly reduced by early diagnosis and by early surgical operation in those cases in which Meckel's diverticulum may possibly be present.

#### REPORT OF CASES<sup>41</sup>

CASE 1.—A white woman aged 20 was admitted to the hospital on June 30, 1938 with a chief complaint of pain in the right lower quadrant of the abdomen. Her history revealed that two years prior to admission she began having periodic attacks of pain in the right lower quadrant of the abdomen, several of which were rather severe and lasted for one or more days. During the two weeks preceding admission she had almost daily attacks of pain in the right lower quadrant of the abdomen. It was noted on the chart that the patient was of a nervous temperament and worried a great deal over minor problems. The physical examination gave essentially negative results except for tenderness of moderate degree in the right lower quadrant of the abdomen, slightly medial to McBurney's point. The red blood cell count was 4,900,000; the value for hemoglobin, 90 per cent (Sahli), and the white blood cell count, 9,500, with polymorphonuclear cells 88 per cent and lymphocytes 12 per cent. Examination of the

urine showed it to be normal. The temperature, 98 F., the pulse rate 82 and the respiratory rate. She was observed overnight in the hospital, and following morning the findings were essentially same. It was decided that operation was indicated. A preoperative diagnosis of appendicitis was made. A right rectus incision was employed. The appendix was found to be normal and exploration of the ileum revealed Meckel's diverticulum, 4 cm. in length, the antemesenteric border, approximately 20 in. (50 cm.) from the ileocecal valve. The diverticulum was removed in a transverse plane, and the stump was closed with two rows of continuous sutures of surgical gut. The wound healed by first intention, and she was dismissed from the hospital on July 7. She was seen two years later and found to be completely relieved of the periodic abdominal distress. Microscopic examination of the tissue removed revealed a diverticulum containing gastric mucosa.

CASE 2.—A girl 8 years old was admitted to the hospital Aug. 31, 1939 with a chief complaint of pain in the right lower quadrant of the abdomen of two days' duration. Her history revealed that she had had no previous attacks similar to the present illness. This attack began with vague generalized pain in the right side of the abdomen associated with nausea and vomiting, which localized to finger point pain in McBurney's area at the time of admission. Physical examination revealed marked tenderness over McBurney's point, voluntary reflex rigidity of the abdominal muscles and audible borborygmus. The temperature was 100.4 F., the pulse rate 108 and the respiratory rate 24. The red blood cell count was 4,640,000; the value for hemoglobin, 80 per cent (Sahli), and the white blood cell count, 11,650, with polymorphonuclear cells 84 per cent and lymphocytes 16 per cent. Urinalysis revealed the presence of acetone. The preoperative diagnosis was acute appendicitis, with probable Meckel's diverticulum. A right rectus incision was employed. The appendix was found to be practically normal. There was a rather marked lymphadenitis in the mesentery of the ileum. Exploration of the ileum revealed a large diverticulum, about 5 cm. in length, on the antemesenteric portion of the ileum, approximately 14 inches (35 cm.) from the ileocecal valve. The appendix and the diverticulum were excised. The stump of the diverticulum was sutured with three rows of fine catgut suture in a transverse plane. The patient was dismissed from the hospital on September 7. Follow-up revealed no recurrence of the abdominal symptoms five years after the operation. The microscopic examination of tissue removed revealed the diverticulum to contain ileal mucosa with no heterotopic tissue present.

CASE 3.—A 9 year old boy was admitted to the hospital on May 7, 1941 with a chief complaint of abdominal pains associated with melena of three days' duration. The illness began May 4, with epigastric pain which migrated to the umbilicus. The patient became weak and pale and appeared to be in a state of mild shock. He passed a number of bloody stools in which there were fresh blood and dark blood clots. He was seen by Dr. Berkeley Neal, who obtained a history of a similar attack two years before associated with intestinal hemorrhage, and another a year later. Roentgenologic studies after the first attack revealed no cause for the bleeding. Physical examination revealed an extreme pallor of the skin. There was slight

40. Harrington, S. W.: Strangulated Meckel's Diverticulum in Right Femoral Hernia, *S. Clin. North America* 6:1180-1190 (Oct.) 1926.

41. Material in cases 1, 2 and 3 was obtained at the Lewis-Gale Clinic, Roanoke, Va., prior to my entrance into active military service. The material in cases 4 to 10 was obtained in the surgical service of a station hospital. Cases 11 and 12 were observed after this paper was originally written.

abdominal tenderness in the area of the umbilicus. The child appeared quite weak from hemorrhage. Proctoscopic examination revealed nothing abnormal. The red blood cell count was 2,690,000; the value for hemoglobin, 55 per cent (Sahli), and the white blood cell count, 3,300, with polymorphonuclear cells 56 per cent and lymphocytes 44 per cent. Urinalysis revealed the pressure of acetone. The temperature was 99.2 F., the pulse rate 98 and the respiratory rate 20. A series of gastrointestinal roentgen studies was made on May 8, 9 and 10 with Meckel's diverticulum in mind. This series was negative. It was decided that the patient probably had Meckel's diverticulum despite the negative roentgenologic findings. A transfusion of 500 cc. of whole blood was administered on May 8. Laparotomy was performed May 12, with a right rectus incision. On entering the abdominal cavity it was found that there was an incomplete rotation of the colon. The cecum was located in the right upper quadrant of the abdomen at the point where the hepatic flexure normally should be. The ileum was retroperitoneal in the distal 12 inches (30 cm.). A diverticulum 6 inches (15 cm.) long arising from the antemesenteric border of the ileum, 14 inches (35 cm.) above the ileocecal valve, was found. It was attached to the abdominal wall at the umbilicus. Several coils of small bowel were looped around the diverticulum producing a partial strangulation of the diverticulum. The diverticulum was released from its attachment to the abdominal wall and removed from the ileum over a Payr clamp. The stump was inverted in a transverse plane with two rows of catgut suture. The appendix was removed. The following day it was apparent that the patient was not doing well and appeared to be in a state of mild shock. He was given parenteral fluids and general supportive measures and seemed to improve. On May 15 he had a large intestinal hemorrhage which continued in spite of transfusions and other supportive measures. It was decided to reopen the abdomen. On May 15 the old incision was reincised and it was found that the inverted stump of the resected diverticulum was bleeding, as well as the mucosa in the adjacent wall of the ileum. It was necessary to resect this portion of the ileum. The distal stump of the ileum was closed near the cecum, and the proximal part of the ileum was anastomosed to the ascending colon. Following this the patient made an uneventful recovery and was dismissed from the hospital on May 29 completely recovered. Communication was received on Jan. 12, 1944, stating that he had no recurrence of the gastrointestinal pain or bleeding. Examination of tissue removed revealed marked inflammation in the wall of the diverticulum and the adjacent ileum. No heterotopic gastric mucosa could be found after careful search by the pathologist.

CASE 4.—A man aged 22 was admitted to the hospital Nov. 19, 1942 with a chief complaint of severe pain in the right lower quadrant of the abdomen of about fourteen hours' duration. He had become ill early the same morning, with generalized abdominal pain followed immediately by nausea and vomiting. During the day the pain migrated to the right lower quadrant of the abdomen and remained severe. His past history revealed nothing of significance. Physical examination revealed slight abdominal distention with acute point tenderness at McBurney's point in the right lower quadrant of the abdomen and rather marked reflex spasm of the musculature of the right side of the abdomen. The temperature was 98.6 F., the pulse rate

96 and the respiratory rate 22. The red blood cell count was 5,050,000; the value of hemoglobin, 80 per cent (Tallqvist), and the white blood cell count, 11,550, with polymorphonuclear cells 78 per cent and lymphocytes 21 per cent. Urinalysis gave normal results. A diagnosis of acute appendicitis was made, because the symptoms seemed to be far more severe than the blood count, temperature and pulse rate would indicate. Operation was performed through a Battle incision, and the appendix was found to be normal. When the ileum was explored, a large diverticulum was found arising from the antemesenteric portion approximately 2 feet (60 cm.) from the cecum. This diverticulum was about 8 cm. in length and contained three saccular projections in the form of pseudodiverticuli, arising from its wall. The diverticulum was removed in a transverse plane, and the stump was closed with 3 rows of fine surgical gut suture. The appendix was removed. The patient made an uneventful recovery and was dismissed from the hospital on December 5. He was last seen in July 1943 and had had no recurrence of his symptoms. Microscopic examination of tissue removed revealed Meckel's diverticulum, with heterotopic duodenal and gastric mucosa.

CASE 5.—A man aged 20 was admitted to the hospital on Oct. 29, 1943 with a chief complaint of pain in the area of the umbilicus and the lower part of the abdomen of two days' duration. He gave a history of having become ill two days prior to admission with vague pains in the area of the umbilicus and the lower midline area of the abdomen. This was followed by a type of indigestion characterized by acid eructations which contained bile. The diagnosis of cholecystitis was made, and he was treated conservatively for two days. When his condition seemed to become worse, he was transferred to this hospital. On arrival here, he was still complaining of vague pains in the lower part of the abdomen, with continued episodes of acid and gaseous eructations and an increasing sensation of abdominal distention. The medical officer who first saw him noted on the chart that he did not look very sick. Physical examination revealed slight to moderate abdominal tenderness just below the umbilicus. There was moderate tympanites. There was no abdominal rigidity. The temperature was 98 F., the pulse rate 76 and the respiratory rate 18. The red blood cell count was 5,150,000 and the white blood cell count 14,050, with polymorphonuclear cells 85 per cent, lymphocytes 13 per cent and eosinophils 1 per cent. The value for hemoglobin was 85 per cent (Tallqvist). He was put to bed and treated conservatively by the medical service. Late in the afternoon of October 30 he was seen in consultation by members of the surgical service. It was ascertained at this time that the patient had had a previous attack similar to the present illness twenty months before, at which time he was treated by siphonage with a Miller-Abbott tube. He made a complete recovery and was free of symptoms except for occasional spells of what he described as indigestion, which seemed to follow certain meals. Physical examination at this time revealed about the same conditions as on the previous day. The white cell count was 5,200, with polymorphonuclear cells 74 per cent and lymphocytes 26 per cent. It was decided to try a Miller-Abbott tube again. The tube was passed; fluids were administered parenterally, and the patient seemed to be improved the following morning. Later in the day (October 31) he pulled the Miller-Abbott tube out and it was necessary to reinsert it. A scout roent-



genogram of the abdomen taken on October 30 revealed what appeared to be an intestinal obstruction in the ileum. It was thought that the obstruction was not complete, since gas and fecal matter were getting through. Conservative treatment was continued on October 31. A blood count on October 31 revealed a white cell concentration of 5,350. The temperature was 98 F., the pulse rate 78 and the respiratory rate 18. On November 1 there was a definite change. His temperature rose suddenly to 101 F., his pulse rate to 128 and his respiratory rate to 28. The pain in the lower part of the abdomen became acutely severe; rigidity developed in the musculature of the abdominal wall, and the white blood cell concentration rose to 17,900, with polymorphonuclear cells 98 per cent and lymphocytes 2 per cent. The abdomen was opened, since it was feared that something had perforated.<sup>42</sup> When the abdominal cavity was entered, a large quantity of purulent fluid was encountered. There was a generalized plastic peritonitis which seemed to originate in the neighborhood of the appendix. Drains were placed in the pelvis and near the cecum and one toward the midline. After this procedure the patient seemed to improve slightly but continued to have a temperature varying between 101 and 102 F., with the pulse rate ranging from 100 to 128. He died on November 10, ten days after the operation. During the postoperative period continuous duodenal siphonage was maintained and feeding was parenteral. Autopsy revealed gangrenous Meckel's diverticulum and generalized peritonitis; associated with this condition was septicemia with acute vegetative endocarditis. Microscopic examination of the diverticulum revealed a gangrenous diverticulitis. Heterotopic gastric mucosa was present.

CASE 6.—A youth aged 18 was admitted to the hospital Dec. 10, 1943 with a chief complaint of abdominal pains of twenty-four hours' duration. The history revealed that he became ill in the afternoon of December 9 with slight abdominal pains centered mainly around the umbilicus which were soon followed by periods of nausea and anorexia. The pains gradually became more severe, so that when he reached the hospital, twelve hours later, he complained of agonizing pains in the lower part of the abdomen. The past history revealed that he had an attack similar to the present illness about one year before, at which time he was sick in bed for a week and was treated conservatively. At that time he was told he probably had appendicitis. Physical examination on his admission to this hospital revealed moderate tenderness in the midline just below the umbilicus. There was no rigidity and no rebound pain, but he complained of severe subjective pains in the lower part of the abdomen. The temperature was 99.4 F., the pulse rate 88 and the respiratory rate 24. The red blood cell count was 4,890,000, and the white blood cell concentration, 11,900, with polymorphonuclear cells 60 per cent and lymphocytes 40 per cent; the value for hemoglobin was 85 per cent (Tallqvist). Owing to the vague nature of the symptoms, it was decided to delay the operation. The following morning the subjective pain was still severe but there was only moderate tenderness, which was in the midline just below the umbilicus. Because of the persistence of the symptoms it was decided that operation was indicated, with the probable diagnosis of

appendicitis. The Battle incision was employed.<sup>43</sup> The appendix was normal. On exploration of the ileocecal junction a Meckel's diverticulum was found about 18 inches (45 to 50 cm.) from the ileocecal valve, measuring 3 cm. in length on the antemesenteric border. It was excised in a transverse plane, and the stump was closed with three rows of fine surgical gut sutures. The appendix was also removed. Recovery was rapid and uneventful. The patient was discharged from the hospital Jan. 1944. Examination of tissue revealed the presence of typical heterotopic gastric mucosa in the diverticulum.

CASE 7.—A man aged 22 was admitted to the hospital Jan. 2, 1944 complaining of rather severe pains in the lower midline region of the abdomen of three days' duration. The cadet stated that on Dec. 30, 1943 he was struck in the abdomen while boxing but that he had no symptoms until six hours after the injury, when he began to have vague pains in the lower part of the abdomen. The pain was intermittent for two days and then began to be almost constant. The morning after admission he became nauseated and vomited and the pains in the abdomen became more severe. The past history was entirely irrelevant. Physical examination revealed the abdomen to be moderately tender in the lower midline region, with moderate rigidity and rebound pain referred to the umbilicus. The temperature was 98.4 F., the pulse rate 80 and the respiratory rate 20. The white blood cell count was 10,500, with polymorphonuclear cells 68 per cent and lymphocytes 32 per cent. Urinalysis gave negative results. After a brief period of observation, it was decided that the patient had an abdominal condition requiring surgical intervention and probably had Meckel's diverticulum. Exploration was carried out through a Battle incision. The appendix was normal, and there was no evidence of injury within the abdominal cavity, but Meckel's diverticulum, 4 cm. in length, was present about 18 to 20 inches (45 to 50 cm.) above the ileocecal valve on the antemesenteric portion of the ileum. The diverticulum was excised in a transverse plane and the stump was closed with two rows of continuous fine surgical gut sutures. The appendix was also removed. The man made an uneventful recovery and was discharged from the hospital January 23. Microscopic examination of the tissues removed revealed the presence of typical heterotopic gastric mucosa within the diverticulum.

CASE 8.—A girl 10 years old was admitted to the hospital Feb. 2, 1944 with the chief complaint of abdominal pain, anorexia and nausea of three days' duration. The history revealed that the patient had been subject to recurrent episodes of abdominal pain with anorexia and slight nausea lasting from two to several days over a period of about one year. She was described as having a finicky appetite, and a great deal had been done in the way of adjusting diets in order to prevent the occurrence of the gastrointestinal symptoms. The present attack began eight days prior to her admission with vague pains in the area of the umbilicus, slight nausea and the complaint of abdominal distress after eating. Physical examination revealed a somewhat thin, small girl with slight tenderness just to the right of the umbilicus and rebound pain referred to the umbilicus. The temperature was 98.6 F., the pulse rate 88 and the respiratory rate 20. The re-

42. Operation was performed by Captain H. W. Gourlie.

43. Operation was performed by Captain G. S. Edger-ton.

blood cell count was 4,850,000, and the white blood cell count, 4,900, with polymorphonuclear cells 36 per cent, lymphocytes 60 per cent and eosinophils 4 per cent. The value for hemoglobin was 80 per cent (Tallqvist). Examination of the stools and of the urine revealed nothing significant. In view of the fact that the patient had been in the hospital on previous occasions for a similar condition and in view of the physical findings, it was decided that operation was indicated. The preoperative diagnosis was probable appendicitis. A Battle incision was employed. The appendix was found to be normal but was removed. Meckel's diverticulum, 5 cm. in length, was found 15 inches (40 cm.) from the cecum on the lateral aspect of the ileum. Its blood supply was derived from its own mesenteric lumen. The diverticulum was excised in a transverse plane, and the stump was closed with three rows of fine surgical gut sutures. The patient made an uneventful recovery and was discharged from the hospital February 12. Follow-up at the time of writing reveals the patient to be gaining in weight and to be relieved completely of her gastrointestinal disturbances. Microscopic examination of the diverticulum revealed the presence of heterotopic gastric mucosa.

CASE 9.—A man aged 46 fell dead after engaging in physical exercise in the line of duty on March 8, 1944. As far as could be determined, his past history was essentially irrelevant. No history could be obtained of any gastrointestinal disturbance. Autopsy revealed the cause of death to be a coronary occlusion. Meckel's diverticulum, 6 inches (15 cm.) long, was found on the small intestine 46 inches (115 cm.) from the cecum. Microscopic examination of the diverticulum revealed the presence of heterotopic gastric mucosa.

CASE 10.—A man aged 25 died March 6, 1944 as a result of injuries received in an airplane crash. As far as could be determined, he had no history of gastrointestinal disease prior to the accident. Autopsy revealed the cause of death to be due to exsanguination from lacerations of large blood vessels in the chest. Meckel's diverticulum, about 8 inches (20 cm.) long, was found on the ileum about 20 inches (50 cm.) from the cecum. Microscopic examination of the diverticulum revealed normal ileal tissue and no heterotopic tissue.

CASE 11.—E. E. S., a white man, aged 55, was admitted to the hospital on July 27, 1944 with the diagnosis of lumbago. He became ill at 8 a. m., while bending over in his routine work. At 4 p. m. of the same day he was complaining of midepigastric pain of increasing severity. The white blood cell count was 11,050, with polymorphonuclear cells 80 per cent and lymphocytes 20 per cent; the red blood cell count was 4,200,000; the value for hemoglobin was 80 per cent (Tallqvist). He was observed until 10 p. m., when the pains in the epigastrium became extremely severe. At this time his abdomen was boardlike in rigidity. His past history revealed that he had had a similar attack six years prior to admission to the hospital, at which time he was in bed for three weeks. There was also a history of frequent episodes of dyspepsia, characterized by gaseous eructations and epigastric distress, over a period of twenty years. About a year before he had been treated for an unconfirmed duodenal ulcer.

With the development of boardlike rigidity in the abdomen and the severe pain, it was decided that exploration was indicated. The possibility of Meckel's

diverticulum was entertained before operation. At operation the appendix was found to be normal. There was no other disease in the abdominal cavity except a diverticulum about 2 inches (5 cm.) long. It was 24 inches (6 cm.) from the cecum on the antemesenteric border of the ileum. The appendix and the diverticulum were removed, and the patient made an uneventful recovery. Microscopic examination of the diverticulum revealed the presence of gastric mucosa without inflammation.

CASE 12.—L. K. was admitted to the hospital on Aug. 11, 1944 with the diagnosis of acute appendicitis. She became ill at 9 a. m. of the same day, with pains in the midepigastrium, associated with nausea and vomiting. She took a laxative and administered an enema to herself. These measures failed to give relief. She was examined at 4 p. m. and found to have moderate tenderness in the right lower quadrant of the abdomen with persistent pain in the midepigastrium. The white blood cell count was 9,000 at 4 p. m. She was advised at this time to remain in bed and rest. She improved slightly, but at 8 p. m. the epigastric pain and nausea returned. She was admitted to the hospital, with a white blood cell count of 12,400. Urinalysis gave normal results. There was distinct tenderness in McBurney's area, but all of the pain of which she complained was in the midepigastrium. The history revealed repeated attacks of mild epigastric distress at intervals during the past two years. The diagnosis was appendicitis, and operation was performed at 11 p. m. The appendix was normal. There was a small follicular cyst on the right ovary, and Meckel's diverticulum, rather large, was situated 12 inches (30 cm.) from the cecum, on the antemesenteric border of the ileum. It was 6 cm. long and contained three small pseudodiverticula. The appendix and the diverticulum were removed, and the cyst on the ovary was punctured. The patient made an uneventful recovery. Microscopic examination of the diverticulum revealed the presence of gastric mucosa without inflammation.

#### COMMENT

The object in presenting these cases is primarily to call attention to the fact that there are cases in which Meckel's diverticulum containing heterotopic gastric mucosa may cause symptoms somewhat akin to those of diverticulitis but in which there is no evidence of inflammation. This type of condition could be called dyspepsia Meckeli. It is believed that the heterotopic gastric mucosa secretes hydrochloric acid and pepsin and that the acid and pepsin become irritating to the ileum, producing spasms in the walls of the ileum and the diverticulum. These spasms, in turn, cause the symptoms. It is therefore recommended that when patients with such symptoms are seen dyspepsia Meckeli be considered and that at operation Meckel's diverticulum be excluded by searching for it.

Case 3 was interesting because simple excision of the bleeding diverticulum did not stop the hemorrhages and two days later it was necessary to resect a portion of the ileum to bring about the desired result.

Delay in operating in case 5, due to failure to recognize the inflammatory nature of the intestinal obstruction, led to a fatal outcome from peritonitis and septicemia. This was partly due to the fact that the patient was once successfully carried through a previous attack with the Miller-Abbott tube and to the fact that he seemed to improve under conservative treatment at the beginning of the last attack. No doubt, had operation been performed earlier the outcome of this case would have been different. It is possible that the occasional episodes of indigestion he had between the first and the last severe attack were due to dyspepsia Meckeli if not to peptic ulcer of the diverticulum.

Cases 9 and 10 were included to show that Meckel's diverticulum occurs without producing symptoms. If symptoms were present in these

cases they were not recognized or were of such clinical intensity.

#### CONCLUSIONS

A general consideration of Meckel's diverticulum and of the 10 cases<sup>44</sup> reported here leads to the following conclusions: 1. If Meckel's diverticulum is suspected at all, early operation is imperative.

2. The treatment of Meckel's diverticulum is surgical removal of the diverticulum.

3. In a certain number of cases of Meckel's diverticulum there is probably a symptom complex resulting from secretion of hydrochloric acid and pepsin by heterotopic gastric mucosa, for which the term dyspepsia Meckeli is suggested.

<sup>44</sup>Two additional cases (cases 11 and 12) were observed after this paper was originally written.

# UTILIZATION OF OXYGEN BY THE BRAIN IN TRAUMATIC SHOCK

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BALTIMORE

Reduction in the effective volume of circulating blood in traumatic shock results in varying degrees of anoxia of the different structures of the body. The nervous system is probably more sensitive than other tissues to a deficit of oxygen and it is likely that irreversible changes take place there first. Many studies have been performed in recent years on metabolism and blood flow in the kidneys, the liver and other organs in shock. The brain has not received sufficient attention in this regard because of difficulties connected with methods for determining the cerebral blood flow and for collecting cerebral venous blood. These difficulties are to a considerable extent anatomic, in that the arterial blood is supplied to the brain through a number of different vessels. In the dog and the cat the external carotid arteries supply a considerable part of the total. As emphasized by Dumke and Schmidt,<sup>1</sup> the monkey resembles man in that the greater part of the cerebral blood flow is conducted by the internal carotid arteries and there are only insignificant communications between the intracranial and the extracranial part of the cephalic circulation.

The best method which has been devised for the direct determination of the blood flow of the brain is that of Dumke and Schmidt,<sup>1</sup> in which one uses a flowmeter after cannulation of the main cerebral arteries of the monkey. The only criticism of their method is that one may be dealing with a somewhat abnormal animal as a result of the experimental preparation itself. An extensive operation and systemic treatment of the blood with heparin are necessary for the conduct of the study. The present studies on dogs consisted of determinations of the oxygen content of arterial blood, of the oxygen content of venous blood obtained from the confluence of cerebral sinuses and of the total oxygen con-

sumption of the animal after shock was produced by several different methods. It was appreciated at the initiation of these experiments that changes in the arteriovenous oxygen difference may not parallel alterations in the cerebral blood flow. At the same time it was hoped that information on the cerebral utilization of oxygen and the total oxygen consumption of the body would shed some light on the manner in which the brain responds to a reduction in blood volume, cardiac output and arterial blood pressure.

## METHODS

Dogs were used in all experiments. General anesthesia was produced approximately one hour before the control studies were performed by the intravenous injection of pentobarbital sodium, 25 to 30 mg. per kilogram of body weight. Subsequent subcutaneous injections were given as indicated, 5 to 10 mg. per kilogram of body weight. Samples of blood were collected under oil in 20 cc. syringes containing sodium oxalate. The oxygen consumption of the animal was determined by a Benedict spirometer. The approximate mean arterial blood pressure was determined by needle puncture of the femoral artery. The cardiac output was calculated by the Fick principle.

Arterial blood for the various analyses was obtained by puncture of the femoral artery. Mixed venous blood was withdrawn from the right auricle after a glass cannula was inserted through the right external jugular vein. Cerebral venous blood was obtained from the confluence of sinuses (torcular Herophili). The occipital protuberance was exposed, and an opening into it was made by means of a small drill. After blood escaped freely, a metal cannula was inserted. This cannula was 23 mm. in length. It had an external diameter of 4.5 mm. at the tip and an internal diameter of 1.5 mm. The distal end of the cannula was tapered and threaded in order to insure a snug fit into the bone. When blood was not being withdrawn, the cannula was plugged by an obturator.

The following methods were used in producing shock. In the experiments on hemorrhage, blood equal to 1 per cent of the body weight was removed at one hour intervals. Samples for the various analyses were withdrawn forty-five minutes after each bleeding. In the studies on burns the hair was clipped over the entire body. The deeply anesthetized animal was then dipped up to the axilla in water at 90 C. for ten seconds. In the experiments on the effects of trauma to an extremity, one of the thighs was struck approximately four hundred moderately severe blows with a hammer. In the studies on the effects of a tourniquet, a strong rubber tube was wrapped tightly about the uppermost part of each posterior extremity and was left in place for four hours before being removed.

From the Department of Surgery of the Johns Hopkins University and Hospital. The work described in his paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Johns Hopkins University.

1. Dumke, P. R., and Schmidt, C. F.: Quantitative Measurements of Cerebral Blood Flow in the Macaque Monkey, *Am. J. Physiol.* **138**:421, 1943.

## RESULTS

Control experiments in which the oxygen content of the sinus blood was determined and other studies were performed over a six hour period showed no great alteration in the various factors during this time. All of the changes were much less marked than those which were found in the subsequent experiments.

All of the four experimental procedures for producing shock, hemorrhage, trauma, tourni-

early increase in the arterial-venous oxygen difference was due in some instances to an increase in the oxygen content of the arterial blood rather than to a decrease in oxygen content of the venous blood. As indicated previously, the arterial-venous sinus oxygen difference usually increased before there was a significant decrease in the arterial blood pressure. Alterations in the total oxygen consumption of the body throughout the course of the exper-

TABLE 1.—The Effects of Graded Hemorrhage

Time	Arterial Blood Pressure, Mm. Hg	Hematocrit Reading	Sinus Blood, Volumes per Cent		Blood from Right Auricle, Volumes per Cent		Arterial Blood, Volumes per Cent		Arteriovenous Difference, Volumes per Cent Oxygen		Oxygen Consumption of Body, Cc. per Minute	Cardiac Output, Cc. per Minute	Blood Removed per Cent Body Weight	Comments
			Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Sinus	Right Auricle				
10:20 a.m. (control)	130	39.0	50.8	12.2	50.9	10.1	45.5	15.9	3.7	5.8	103	1,777	...	Weight 12.2 Kg.; pentobarbital sodium 30 mg. per Kg.
10:35	...	...	...	...	...	...	...	...	...	...	...	...	1	Pentobarbital sodium 5 mg. per Kg.
11:20	123	42.4	45.7	11.7	45.6	13.2	40.6	18.2	6.5	5.0	107	2,140	1	Pentobarbital sodium 5 mg. per Kg.
11:35	...	...	...	...	...	...	...	...	...	...	...	...	1	
12:20 p.m.	128	44.0	40.8	13.2	42.8	12.8	37.1	18.8	5.6	6.0	97	1,617	...	
12:35	...	...	...	...	...	...	...	...	...	...	...	...	1	
1:20	120	41.8	41.4	8.2	40.0	7.0	31.6	18.2	10.0	11.2	106	946	1	
1:35	...	...	...	...	...	...	...	...	...	...	...	...	1	
2:20	115	42.6	37.2	9.2	35.6	9.6	27.3	18.0	8.8	8.4	131	1,560	1	
2:35	...	...	...	...	...	...	...	...	...	...	...	...	1	
3:20	48	38.9	32.3	5.5	32.8	4.2	18.3	16.7	11.2	12.5	114	912	...	
3:35	...	...	...	...	...	...	...	...	...	...	...	...	1	
3:50	...	...	...	...	...	...	...	...	...	...	...	...	...	Died

TABLE 2.—The Effects of Trauma to An Extremity

Time	Arterial Blood Pressure, Mm. Hg	Hematocrit Reading	Sinus Blood, Volumes per Cent		Blood from Right Auricle, Volumes per Cent		Arterial Blood, Volumes per Cent		Arteriovenous Difference, Volumes per Cent Oxygen		Oxygen Consumption of Body, Cc. per Minute	Cardiac Output, Cc. per Minute	Comments
			Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Sinus	Right Auricle			
10:40 a.m. (control)	130	44.3	45.5	13.5	46.2	13.0	43.9	16.8	3.3	3.8	117	3,079	Weight 12.3 Kg.; pentobarbital sodium 28 mg. per Kg. Trauma to left leg
11:00-11:10	...	...	...	...	...	...	...	...	...	...	...	...	
11:40	128	51.6	42.0	12.3	39.8	13.2	33.6	19.8	7.5	6.6	111	1,682	
12:50 p.m.	103	53.2	41.6	11.2	39.1	9.1	29.7	21.7	10.5	12.0	127	1,008	Pentobarbital sodium 10 mg. per Kg. subcutaneously
2:40	110	52.7	41.0	12.3	41.4	8.5	28.9	21.4	9.1	12.9	122	946	
4:40	80	51.3	37.4	11.2	35.8	10.0	27.6	21.5	10.3	11.5	115	1,000	3:30: pentobarbital sodium 10 mg. per Kg. subcutaneously
5:40	83	...	...	...	...	...	...	...	...	...	...	...	Pentobarbital sodium 5 mg. per Kg. subcutaneously
7:40	70	50.7	35.5	9.0	35.4	6.7	23.9	21.0	12.0	14.3	114	795	
9:10	35	50.8	32.7	4.1	33.6	1.9	23.7	18.3	14.2	16.4	...	...	
9:20	...	...	...	...	...	...	...	...	...	...	...	...	Died

quents and burns were associated with an increase in the arteriovenous difference of both the cerebral sinus blood and the mixed venous blood. The oxygen utilization of the cerebral sinus blood and that of the mixed venous blood in general paralleled each other closely. Particular attention is directed to the fact that the difference in oxygen content of the arterial blood and that of the sinus blood increased in the early stages of shock and this difference usually became more marked as shock developed. The

ments were not great. If one could assume that the oxygen consumed by the brain also remained essentially constant, the finding of an increased utilization of oxygen would mean that the cerebral blood flow was considerably reduced. Such an assumption is not warranted. The results of representative experiments are given in tables 1, 2, 3 and 4.

## COMMENT

It is to be emphasized that the measurement of the quantity of oxygen which is removed from

each unit of blood which passes through the brain may not give a direct<sup>2</sup> indication of the cerebral blood flow. Schmidt and his associates stated the opinion that there is no correlation between the cerebral arteriovenous difference and the cerebral blood flow.

The present studies on utilization of oxygen by the brain are of interest in comparison with

flow through the kidney has been reduced to less than half of that in the preshock state. Bradburn and I<sup>4</sup> found a number of years ago that the oxygen content of blood in the renal vein was altered relatively little in various types of shock. It is to be noted in the present experiments that the arteriovenous oxygen difference in cerebral blood is usually considerably

TABLE 3.—*The Effects of Tourniquets*

Time	Arterial Blood Pressure, Min. Hg	Hematocrit Reading	Sinus Blood, Volumes per Cent		Blood from Right Auricle, Volumes per Cent		Arterial Blood, Volumes per Cent		Arteriovenous Difference, Volumes per Cent Oxygen		Oxygen Consumption of Body, Cc. per Minute	Cardiac Output, Cc. per Minute	Comments
			Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Sinus	Right Auricle			
12:20 a.m. (control)	125	50.7	57.3	7.5	52.0	10.0	48.2	13.6	6.1	3.6	132	3,695	Weight 16.5 Kg.; pentobarbital sodium 25 mg. per Kg.
10:35	...	...	...	...	...	...	...	...	...	...	...	...	Tourniquets on both hindlegs; 11:30: pentobarbital sodium 10 mg. per Kg. subcutaneously
2:35 p.m.	...	37.2	48.9	13.3	47.2	13.3	44.2	18.6	5.3	5.3	186	3,510	
2:30	143	49.8	45.5	13.5	43.0	14.3	39.3	20.0	6.5	5.7	150	2,632	
2:40	...	...	...	...	...	...	...	...	...	...	...	...	Tourniquets removed
3:10	105	46.8	38.5	10.2	32.2	14.7	27.4	21.7	11.5	7.0	153	2,185	
4:10	80	52.3	37.1	10.3	33.8	13.9	25.2	23.4	13.1	9.5	150	1,578	
5:40	70	57.1	42.4	5.4	35.0	10.9	22.8	23.0	17.8	12.1	167	1,379	

TABLE 4.—*The Effects of Burns*

Arterial Blood Pressure, Min. Hg	Hematocrit Reading	Sinus Blood, Volumes per Cent		Blood from Right Auricle, Volumes per Cent		Arterial Blood, Volumes per Cent		Arteriovenous Difference, Volumes per Cent Oxygen		Oxygen Consumption of Body, Cc. per Minute	Cardiac Output, Cc. per Minute	Comments
		Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Carbon Dioxide	Oxygen	Sinus	Right Auricle			
128	48.1	48.5	13.8	50.1	11.6	47.1	15.9	2.1	4.3	95	2,208	Weight 14 Kg.; pentobarbital sodium 20 mg. per Kg. Burn 90 C. 10 seconds
...	....	....	....	....	....	....	....	...	...	...	.....	
90	52.0	43.3	15.7	43.1	14.4	37.6	20.3	4.6	5.9	85	1,492	
100	51.7	46.5	11.5	42.5	13.3	37.5	20.5	9.0	7.2	91	1,263	12:00: pentobarbital sodium 5 mg. per Kg.
108	58.4	43.1	12.9	39.4	13.8	32.2	23.1	10.9	9.3	125	1,376	1:30: pentobarbital sodium 5 mg. per Kg.
113	....	....	....	....	....	....	....	...	...	...	.....	Pentobarbital sodium 5 mg. per Kg.
108	64.8	38.4	12.1	34.9	13.7	24.0	26.8	14.7	13.1	104	794	5:00: pentobarbital sodium 5 mg. per Kg.
75	63.8	34.1	10.0	30.0	13.6	17.2	25.4	18.4	14.8	109	737	
70	73.9	33.5	6.5	30.6	8.1	11.1	29.2	22.7	21.1	59	469	
..	....	....	....	....	....	....	....	...	...	...	.....	Died

1 other organs, particularly the kidneys,

2 Van Slyke and his associates<sup>3</sup> found quantity of oxygen removed from each blood passing through the kidney is not appreciably until peripheral circulatory

3 s passed the initial stages and the blood

4 niddt, C. F.: Personal communication to the

5 Slyke, D. D.; Phillips, R. A., and others: omunication to the author, 1943.

increased in the early stages of traumatic shock. Thus it appears that under conditions of decreasing blood flow the brain, unlike the kidneys, can maintain its oxygen consumption at least partially by extracting increased proportions of oxygen from the arterial blood.

Clarabelle Puryear and Vivien Thomas rendered valuable technical aid.

4. Blalock, A., and Bradburn, H.: Distribution of the Blood in Shock, Arch. Surg. 20:26 (Jan.) 1930.

## TREATMENT OF TRAUMATIC ANEURYSMS AND ARTERIOVENOUS FISTULAS

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Traumatic aneurysms and arteriovenous fistulas were frequent sequelae of vascular injuries during the last great war and from current reports are even more numerous during the present war. This is not unexpected, for the type of armament now being used characteristically produces multiple wounds. Furthermore, in the past wounds of major blood vessels caused a high mortality as the result of hemorrhage, shock and infection. Now the presence of more highly trained medical officers in the forward areas, more rapid transportation and the use of large quantities of plasma and blood have greatly reduced the number of deaths from hemorrhage and shock. Also the combination of better surgical procedures performed earlier plus the use of sulfonamide compounds has resulted in a lower incidence of infection. The net result of these improvements is the survival of a larger number of soldiers with vascular injuries, in many of whom aneurysms and arteriovenous fistulas develop. It is therefore desirable to attempt to evaluate the various procedures used in the treatment of these important conditions. This task is undertaken in the present paper, which is based largely on a study of 29 patients who had vascular lesions caused by trauma. Thirteen had arteriovenous fistulas, 15 had arterial aneurysms and 1 had an aneurysm of the abdominal aorta and a fistula between the aorta and the vena cava. When the patient last referred to was first seen the aneurysm had ruptured; so careful study was not possible, and the fistula was not localized at that time. It was treated later, independently of the aneurysm.

The physiologic effects of arterial aneurysms are less complex than those of arteriovenous fistulas. With an arterial aneurysm the effects are largely confined to the area supplied by the injured artery, whereas an arteriovenous fistula may produce profound effects on the entire circulatory system. This should be kept in mind

in the management of the two conditions, the same general principles are applied in treatment of both.

A traumatic arterial aneurysm is usually result of injury to an artery deeply embedded in the soft tissues, more often in an extremity in the neck than in one of the great body cavities for a wound of a vessel in one of the latter situations frequently results in fatal hemorrhage. The sequence of events usually is as follows: The weapon or missile penetrates the soft parts, including muscle and fascia, and then the artery. As the result of muscular contraction the tissue planes are shifted and the blood is trapped, forming a hematoma which communicates with the lumen of the artery. The blood in contact with the tissues clots, forming an irregular cavity which gradually becomes more or less spherical. In the early state the lesion is called a pulsating hematoma, but when it becomes well localized and spherical it is called a traumatic or false aneurysm. This paper is concerned with the latter condition.

It is generally agreed that once localization has occurred surgical intervention should be delayed to permit improvement in the collateral circulation and disappearance of bacteria from the adjacent tissues. Unless complications arise which demand earlier operation, conservative treatment should be continued for at least six to eight weeks. The developments most likely to indicate earlier operation are: increase in size of the aneurysm causing compression of collateral channels or adjacent nerve trunks; infection, and secondary hemorrhage. Injury to important nerves at the time of the arterial injury also calls for operation as early as is compatible with reasonable safety.

The type of operation to be performed is determined to a considerable extent by the presence or absence of complications and by the type of complication. As was pointed out by Elkin and Woodhall,<sup>1</sup> injury to important nerves in association with vascular lesions requires excision of the aneurysmal sac and repair of the nerves at the same operation whenever this is possible.

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Read before the Section on Surgery, General and Abdominal, at the Ninety-Fourth Annual Session of the American Medical Association, Chicago, June 14, 1944.

1. Elkin, D. C., and Woodhall, B.: *Ann. Surg.* 119: 411 (March) 1944.

This is desirable, but the interruption of nerve function by the pressure of an expanding aneurysm is not necessarily an indication for excision of the aneurysmal sac, for any procedure which relieves pressure, such as aneurysmorrhaphy, if performed early will be followed by return of nerve function. It is important, therefore, that a careful neurologic examination be done on any patient with a traumatic vascular lesion, especially when the subclavian, axillary, brachial or popliteal artery is involved. Not only should a primary neurologic examination be done, but this should be repeated whenever there is undue pain originating in the region of the aneurysm or when there is rapid enlargement of the aneurysmal sac.

Infection alone may be treated conservatively, but careful watch must be kept for secondary hemorrhage, and if it occurs immediate operation is indicated. The type of operation is dependent on the extent and severity of the infection as well as on the location of the aneurysm. If the infection is mild and especially if the aneurysm is so located that exposure of the artery proximal to the infection is difficult or fraught with unusual danger, the sac may be opened and the artery doubly ligated and completely divided between the ligatures. If, on the other hand, the artery can be readily exposed proximal to the area of infection and obstructed without interfering with essential collateral channels, proximal ligation of the artery and of the concomitant vein may be the treatment of choice. The following case report illustrates the value of proximal ligation of the artery and the vein under suitable conditions.

#### REPORT OF A CASE

W. A., a Negro man apparently about 35 years of age, entered St. Philip Hospital, Richmond, Va., Jan. 12, 1938, because of an infected wound of the lateral side of the left leg at the level of the knee. He had been stabbed ten days before and stated that there was profuse bleeding, which was controlled by external pressure. He was not confined to bed for the first few days, and approximately one week after the injury the leg became swollen and painful. Four days later he had a secondary hemorrhage. When he was admitted to the hospital there was slight bleeding from the wound, which was infected. There was marked swelling about the knee, and filling the popliteal space was a pulsating mass which extended laterally to the region of the stab wound. There was a systolic bruit over this mass. The other significant physical findings were as follows: A systolic murmur was heard at the cardiac apex and over the aortic area; the blood pressure was 170 systolic and 100 diastolic; the volume of the pulse in the posterior tibial and the dorsalis pedis artery was approximately equal in the two extremities, and the left leg and foot were warm.

The important laboratory findings were 2,800,000 red blood cells, 15,750 leukocytes, 84 per cent polymorphonuclear neutrophils and a positive Wassermann reaction of the blood and the spinal fluid.

Six days after admission to the hospital the patient had another hemorrhage so it was decided that proximal occlusion of the artery and vein had best be done. The femoral vessels were exposed in the adductor canal, and the artery was occluded by a strip of fascia and the vein ligated. Pulsation in the aneurysm promptly ceased and was not again noted. There was no further hemorrhage, and the wound healed satisfactorily. The posterior tibial and dorsalis pedis arteries no longer pulsated, but the collateral circulation was adequate. The patient was discharged from the hospital twenty-eight days after occlusion of the femoral artery. At the time of writing, six years later, he has no evidence of aneurysm and appears to have little difficulty with the circulation in the left leg and foot.

In another patient a false aneurysm of the proximal portion of the radial artery of five months' duration was cured by ligation of the terminal portion of the brachial artery. Although the result was satisfactory, aneurysmorrhaphy would have been a better procedure.

Proximal occlusion of the artery and the vein may be the procedure of choice under circumstances similar to those which developed in the first case. It may also be indicated when shrinkage must be caused in an aneurysmal sac to permit exposure of the vessels distally. In most other circumstances a more direct attack on the aneurysm should be employed.

#### CASES PRESENTED IN TABLE 1

Five patients with traumatic arterial aneurysms were treated by complete excision of the aneurysmal sac (table 1).

In the first patient represented in this table the median nerve was found to have been partially divided but healing seemed satisfactory except for an excess of scar; so the nerve was not resected. The radial nerve was moderately compressed but intact. The ulnar nerve was spread out to form a part of the wall of the sac, but when dissected away from the rest of the sac it appeared to be practically intact. At the time of writing, seventeen months later, there is no return of function in those fibers of the median nerve which supply the flexor digitorum profundus muscle, and sensation has not completely returned to that part of the hand which is supplied by the median nerve.

The case of patient 2 in table 1 is also of interest in that, according to the patient's history, only a small, hard mass persisted in the region of the stab wound until four weeks before he was admitted to the hospital, seventeen months after the injury. At that time the mass enlarged rapidly, producing severe pain and pronounced weakness of the muscles of the forearm and hand. On the patient's admission the mass was 5.5 by 4 by 4 cm. and did not pulsate. There was neither thrill nor bruit over it, and when the



sac was excised its lumen was completely filled with clot. The cords of the brachial plexus were firmly attached to the sac but showed no evidence of primary injury. This patient left the hospital on the fifth postoperative day, and even then there was considerable improvement in function of the muscles of the hand and the forearm. It has not been possible to examine him again.

No follow-up of patient 2 has been possible. Patient 3, a 14 year old boy, has not been examined recently, but his local physician states he now, nine months after operation, has no disability of any kind. Since his common femoral artery was occluded, this result is of particular interest. The lumbar sympathetic nerves were interrupted by the injection of alcohol, and

TABLE 1.—*Traumatic Arterial Aneurysms Treated by Complete Excision of Sac*

Patient and Age	Involved Artery	Type of Injury; Duration	Result	Complications and Comment
1. N. B.* 26 yr.	Axillary artery, terminal portion	Bullet wound, 6 wk.	Aneurysm cured	Patient came to hospital because of severe pain and weakness of forearm; sac excised and nerves liberated; temporary weakness of all muscles of forearm; has recovered all motor function except flexion of distal joints of the index and middle fingers (median nerve)
2. J. H.* 27 yr.	Axillary artery	Stab wound; 1½ yr.	Aneurysm cured	Small mass persisted after injury and rapidly enlarged 4 weeks before coming to hospital; on admission radial pulse not palpable; marked weakness of muscles of hand and forearm; no gross nerve injury found; not possible to follow up
3. R. A.* 19 yr.	Deep volar arch	Stab wound; 3 wk.	Aneurysm cured	
4. W. D. 75 yr.	Superficial temporal artery	Blunt force; 3 wk.	Aneurysm cured	
5. V. M. 24 yr.	Radial artery	Stab wound; 3 wk.	Aneurysm cured	

\* Wassermann reaction positive.

TABLE 2.—*Traumatic Arterial Aneurysms Treated by Aneurysmorrhaphy*

Patient and Age	Involved Artery	Type of Injury; Duration	Result	Complications and Comment
1. C. O.* 25 yr.	Abdominal aorta at level of inferior mesenteric artery	Bullet wound; 16 mo.	Aneurysm cured	Abdominal pain which became progressively more severe; patient also had physical signs of arteriovenous fistula within abdomen; see table 5 and case report 3
2. A. C. 29 yr.	Femoral artery in Hunter's canal	Bullet wound; 5 mo.	Aneurysm cured	Mild infection, temporary sinus formation; no appreciable interference with nutrition of lower part of leg and foot at time of discharge from hospital; claudication on fast walking
3. J. N. 14 yr.	Common femoral artery	Stab wound of artery, about ¾ divided in oblique direction; 10 days	Aneurysm cured	Early operation because of severe pain in distribution of femoral nerve; lumbar sympathetic nerves blocked with alcohol
4. J. J. 28 yr.	Axillary artery	Stab wound, artery almost completely divided; 1 mo.	Aneurysm cured	Operation necessary at end of 1 month because of rapid enlargement of aneurysm, causing serious interference with collateral circulation; pressure on cords of brachial plexus caused severe pain and weakness of muscles of arm and hand
5. E. W. 30 yr.	Profunda femoris artery, close to main trunk	Bullet wound; 5 mo.	Aneurysm cured	Opening in common femoral artery closed by suture; distal movement of profunda femoris artery ligated; circulation in main trunk not disturbed
6. R. W.† 45 yr.	Proximal portion of brachial artery	Stab wound; 6 wk.	Aneurysm cured	Patient entered hospital because of rapid increase in size of aneurysm, severe pain and rapid loss of function in all muscles of forearm; no gross nerve lesion demonstrated; postoperative weakness of muscles supplied by radial nerve; anesthesia of index and middle fingers; patient signed release 5 days after operation
7. W. B.† 27 yr.	Distal portion of brachial artery	Stab wound; 7 wk.	Aneurysm cured	
8. R. A.† 23 yr.	Midportion of brachial artery	Stab wound; 1 mo.	Aneurysm cured	Impairment of sensation in distribution of median nerve; patient requested to return to outpatient clinic but failed to do so; no follow-up possible
9. W. L.† 26 yr.	Distal portion of brachial artery	Bullet wound; 13 mo.	Aneurysm cured	Temporary impairment of sensation in distribution of median nerve; complete recovery

\* Previously reported in *Ann. Surg.* 112:879, 1940.

† Wassermann reaction positive.

#### CASES PRESENTED IN TABLE 2

Nine patients with traumatic arterial aneurysms were treated by aneurysmorrhaphy (table 2).

Unfortunately follow-up examinations have been possible in only a small number of these cases. In patient 1 there developed a severe ischemic neuritis with marked temporary disturbance of sensation and motion. Ligation of the vena cava probably would have prevented this complication.

possible that this circumstance is partly responsible for the satisfactory state of the circulation in the involved leg. The preservation of collateral channels incidental to aneurysmorrhaphy may also have played a part in the result.

Patient 4 now, five months after operation, shows complete return of motor function except for weakness of the biceps brachii muscle. It is probable that its nerve supply from the musculocutaneous nerve was injured at the time

of the vascular injury and that this was overlooked in the early neurologic examination.

The case of patient 5 illustrates the importance of determining whether or not the main artery is injured before occluding it. In this case the circulation in the femoral artery has remained intact, and there has been no disturbance in function.

Seven arteriovenous fistulas were treated by quadruple ligation and excision of the fistulous area (table 3).

involved, there is definite evidence that the circulation is inadequate for sustained muscular activity. This is an important matter and one which has not received the attention which is its due.

#### CASES PRESENTED IN TABLE 4

Three traumatic arteriovenous fistulas were treated by repair of an artery (table 4).

R. E. B., a white man 55 years of age (table 4, patient 2), was admitted to the Medical College of

TABLE 3.—*Traumatic Arteriovenous Fistulas Treated by Quadruple Ligation and Excision of the Fistulous Area*

Patient and Age	Involved Vessels	Type of Injury; Duration	Result	Complications and Comment
1. S. B. 46 yr.	Superficial femoral artery and vein, midportion	Bullet wound; 6 mo.	Cure of fistula	Visible pulsation in distal stump of femoral artery after resection and palpable pulse in both dorsalis pedis and posterior tibial arteries at completion of operation; in spite of this, involved leg tires rapidly, and foot is cold
2. E. W.* 18 yr.	Midportion of superficial femoral artery and vein	Bullet wound; 2½ mo.	Cure of fistula	Six weeks after operation leg measurements normal; no symptoms; follow-up not possible
3. A. H. 32 yr.	Common femoral artery and vein near level of profunda femoris artery	Bullet wound; 4 yr.	Cure of fistula	No immediate evidence of circulatory deficiency; no pulse in involved leg during hospital stay; his physician now, 7½ years later, reports weak pulse in popliteal and posterior tibial arteries; foot susceptible to cold; claudication on fast walking or on walking up hill; calf of leg 4 cm. larger than other (normal) leg
4. R. B. 24 yr.	Common femoral artery and vein	Bullet wound; 2 mo.	Cure of fistula	Postoperatively weak dorsalis pedis pulse; 3 years later weak pulse in dorsalis pedis and posterior tibial arteries; foot cold; slight swelling of leg; claudication on walking 2 blocks
5. S. W. 35 yr.	Popliteal artery and vein	Bullet wound; 14 yr.	Cure of fistula	Vein proximal to fistula approximately three times size of vein distal to fistula; ulcer on anteromedial surface of lower part of leg of 3 months' duration at time of operation; healed slowly; then broke down again in 1942—5 years later; healed again; then recurred 1 year later; unable to make examination at this time
6. C. A. 16 yr.	Popliteal artery and vein	Bullet wound; 8 mo.	Cure of fistula	Dorsalis pedis pulse present (small volume) after resection of vessels; now, 7 years after operation, in army hospital awaiting discharge because of swelling and rapid tiring of leg; complaints of coldness of foot
7. J. M.* 28 yr.	External carotid artery and posterior facial vein	Stab wound; 5 yr.	Cure of fistula	Two days after operation a systolic bruit heard anterior to auditory canal; cause undetermined; follow-up not possible

\* Wassermann reaction positive.

TABLE 4.—*Traumatic Arteriovenous Fistulas Treated by Repair of Artery*

Patient and Age	Involved Vessels	Type of Injury; Duration	Result	Complications and Comment
1. C. S.* 55 yr.	Common carotid artery and internal jugular vein	Stab wound; 23 mo.	Cured	Patient examined May 8, 1944, 10½ years later; has remained well; carotid artery has remained patent
2. R. B. 55 yr.	Common carotid artery and internal jugular vein	Bullet wound; 37 yr.	Remained well for 2 yr. and 8 mo.; then false aneurysm developed	Obliterative aneurysmorrhaphy for false aneurysm; proximal and distal ligation of artery; recurrent hemorrhage finally caused death; see report of second case reported
3. C. P. 10 yr.	Common femoral artery and vein	Bullet wound; 6 wk.	Cured	At operation fistula between artery and vein was divided, and openings in artery and vein were closed by fine silk sutures; false aneurysm, lateral side of artery and about 2 cm. in diameter, resected and artery repaired; artery and vein remained patent; 3 years later no demonstrable difference in circulation in two extremities

\* Surgery 2:555, 1937.

#### CASES PRESENTED IN TABLE 3

Excellent immediate results were obtained in the 7 patients represented in this table, but the late results are less satisfactory. In 1 patient there was no evidence of circulatory deficiency at the end of six weeks, but a late follow-up was not possible. In 5 other patients, in whom important vessels of the extremities were also

Virginia Hospital, Richmond, Va., April 3, 1940, complaining of shortness of breath and progressive loss of strength. Thirty-seven years before this he had received a bullet wound in the right side of his neck, and since then he had noted a pulsating mass at the site of injury. Examination showed a small pulsating mass in line with the carotid artery and the internal jugular vein at the level of the thyroid cartilage. There was a loud, continuous, machinery-like murmur over this mass, radiating along the course of these vessels.

The blood pressure was 180 systolic and 80 diastolic. Pressure over the fistula caused slowing of the pulse from 80 to 66. The cardiothoracic ratio was 57 per cent. At operation the aforementioned artery and vein were found separated by a false aneurysm about 2.5 cm. in diameter, through which they communicated. The vein was ligated proximal and distal to the fistula; the aneurysm was opened widely, and the opening in the artery, which was surrounded by a heavy deposit of calcium, was closed by interrupted mattress sutures of fine silk. The aneurysmal sac was obliterated by silk sutures and the vein used to cover the area of repair.

The morning after the operation the patient's blood pressure was 200 systolic and 110 diastolic and the cardiothoracic ratio 56 per cent.

Ten days later the blood pressure was 155 systolic and 95 diastolic and the cardiothoracic ratio 51 per cent. Recovery was uneventful.

hematoma was entered, empyema developed and the ligature of the innominate artery cut through fatal hemorrhage.

While the results in 2 of the cases sent in table 4 were excellent, the unfortunate outcome in the other case may justifiably raise doubt as to the value of arterial repair. In reality the result in the third case should be attributed to the misapplication of a procedure and not to the procedure itself, for the presence of heavy deposits of calcium in the wall of the artery was a definite contraindication to suture of the arterial end of the fistula. Suture was carried out in spite of this because it was feared that resection of the fistulous area would result in inadequate cerebral circulation. Proximal

TABLE 5.—Traumatic Arteriovenous Fistulas Treated by Atypical or Incomplete Operative Procedures

Patient and Age	Involved Vessels	Type of Injury; Duration	Operative Procedure	Complications and Result
1. L. R.* 32 yr.	External iliac artery and vein	Bullet wound; large traumatic aneurysm extending into pelvis and apparently not immediately connected with fistula; 9 mo.	Ligation of external iliac artery, common iliac vein and common femoral vein; fine silk sutures passed through wall of unopened vein to close opening in artery	Bruit with marked systolic accentuation detected 13 days after operation; arterial aneurysm did not pulsate; local physician stated there is now little demonstrable difference in legs, but involved leg tires more rapidly; no swelling; preoperatively swelling was marked
2. O. C.† 25 yr.	Abdominal aorta and inferior vena cava	Bullet wound; 3 yr. and 5 mo.	Aorta ligated with cotton tape proximal to fistula; fistula closed with silk sutures passed through wall of unopened vena cava	Fistula remained closed; tape cut through wall of aorta 3 months after ligation, causing fatal hemorrhage; see accompanying text
3. L. M. 18 yr.	Posterior tibial artery and vein	Bullet wound; 4 wk.	Ligation of artery and vein proximal to fistula	Fistula not found; bruit disappeared after ligation of posterior tibial artery and vein and did not recur while patient was under observation, approximately 10 weeks; no late follow-up possible
4. R. J. 10 yr.	Distal portion common carotid artery and internal jugular vein	Bullet wound; artery and vein communicated through false aneurysm sac which overlies proximal portion of both internal and external carotid arteries; 14 mo.	Ligation of vein proximal and distal to fistula; occlusion of common carotid artery proximal to fistula by strip of fascia	Artery occluded proximal to aneurysm with hope of reducing size of sac, thereby making exposure of the internal carotid artery less difficult; second operation unnecessary; aneurysm and fistula well 3 years and 6 months after operation

\* Wassermann reaction positive.

† Ann. Surg. 112:879, 1940.

Two years and eight months later a false arterial aneurysm developed at approximately the site of repair of the arteriovenous fistula. The aneurysm enlarged rapidly and caused severe pain; so the artery was exposed proximal to the aneurysm and occluded by a strip of fascia. The tenseness of the mass and the force of the pulsations were diminished for only a few days. There was no evidence of interference with the cerebral circulation; so the carotid artery was ligated distal to the aneurysm, and the sac was incised, the clot evacuated and the opening in the artery sutured (obliterative aneurysmorrhaphy). The vessel was extremely sclerotic, and there was moderate bleeding when the clot was evacuated, indicating that the fascial occlusion was no longer complete. Because of the marked degree of sclerosis, it was feared the sutures might give way; so a ligature was applied adjacent to the strip of fascia. A low grade infection developed, however, and the ligature cut through, causing secondary hemorrhage. Repeated attempts were made to control the bleeding, including a transpleural ligation of the innominate artery, but in the exposure of this vessel an infected

distal ligation of the vein and subtotal occlusion of the artery by a strip of fascia as a preliminary procedure, followed by excision of the fistulous area when it had been established that there was an adequate collateral circulation, would have been the method of choice.

#### CASES PRESENTED IN TABLE 5

Four arteriovenous fistulas were treated by atypical or incomplete operative procedures (table 5).

C. C., a white man 25 years of age at the time of this, his first, admission (table 5, patient 2), was operated on Dec. 14, 1938, in the Memorial Hospital, Richmond, Va., for a ruptured aneurysm of the distal portion of the abdominal aorta. At operation, the aorta was occluded, a continuous thrill of the fistula found with arteriovenous fistulas was noted in the region

2. Bigger, I. A.: Surgery 112:879 (Nov.) 1941

adjacent to the aneurysm, but because of difficult circumstances a careful search was not possible, and the site of the fistula was not discovered. After occlusion of the aorta the thrill disappeared, and it had not reappeared one month later, when the abdomen was entered for repair of the opening between the aneurysm and the aorta. A faint thrill and a bruit were noted five months later, and one year after the aneurysmorrhaphy both thrill and bruit had become pronounced and were most distinct just to the right of the midline, 4 cm. above the level of the umbilicus. The part was not enlarged.

When the patient was again examined, in January 1941, the thrill and the bruit were intense and radiated downward on the right to the inguinal ligament but not beyond, a fact which seemed to point to the mesenteric vessels as the site of the fistula. For several months the patient had complained of increasingly severe pain in the lower part of the abdomen, and it had been necessary to give him morphine repeatedly. Roentgen examination of the spine and of the gastrointestinal tract gave negative results save for a moderate degree of stenosis of the third portion of the duodenum. This was attributed to scar, as that portion of the duodenum had been freed for exposure of the aorta at operation and rupture of the aneurysm.

A few days after this examination the patient returned to the hospital because he had fainted, and it was feared that the aneurysm had recurred and had again ruptured. Nothing was discovered to explain the dominal pain; so exploratory laparotomy was performed on March 4, 1941. A very pronounced thrill was present along the right side of the terminal portion of the aorta, and a fistula was found between the aorta and the vena cava just below the level at which aneurysmorrhaphy had been done. There was no recurrence of the arterial aneurysm. There were many intra-abdominal adhesions, and these were especially dense between the left side of the colon and the adjacent structures. The third part of the duodenum was constricted by scar and was freed. The aorta and the vena cava were firmly adherent to each other. They were liberated proximal to the fistula. During an attempt to dissect out the vessels distally so as to be able to control the circulation during repair of the fistula, the right common iliac vein was torn. The hemorrhage was profuse and difficult to control. The aorta was gated above the fistula with cotton tape and the rent in the vein closed by silk sutures. The vena cava was so ligated. The patient showed moderate shock; so an attempt was made to close the fistula. After this operation there was no evidence of circulatory deficiency in the lower extremities. This was especially interesting, for after the previous occlusion of the aorta the circulation in the lower extremities was seriously disturbed. No doubt the chief factor in the maintenance of a satisfactory supply of blood to the lower extremities after the second occlusion of the aorta was obstruction of the vena cava proximal to the fistula.

Eight weeks after ligation of the aorta and the vena cava the fistula was closed with mattress sutures of fine silk, which were passed through the anterolateral wall of the vein, the anterior margin of the opening in the aorta, the posterior margin and the posterolateral wall of the vein and then back in the reverse order. The thrill and the bruit disappeared and did not recur. The patient continued to complain of severe abdominal pain but otherwise made a satisfactory recovery and was discharged from the hospital May 6, 1941, two weeks after operation.

Three and one-half months after ligation of the aorta and six weeks after closure of the fistula there was a

massive hemorrhage into the duodenum, and death occurred approximately twenty-four hours later.

Autopsy showed that the tape had cut through the wall of the aorta, which then ruptured into the third part of the duodenum. Both the arteriovenous fistula and the arterial aneurysm appeared to be well healed (see figure). Nothing was found to explain the severe abdominal pain.

Although 2 of the 4 patients referred to in table 5 were apparently cured by atypical or incomplete operations, it is evident that frequent failures are to be expected. It seems reasonable, therefore, to state that complete ligation of the vessels and excision of the fistulous area or suture of the arterial opening should be done in one stage unless there are excellent reasons for some other procedure's being followed. In the case of patient 1 the presence of a very large false aneurysm in an area difficult of approach was considered sufficient justification for not excising the aneurysm and the fistula. The vein was therefore ligated both above and below the fistula, which was then closed with mattress sutures of fine silk inserted through the wall of the unopened vein. Arterial repair under direct vision through the opened vein would have permitted more accurate placement of the sutures, and since the vessels could readily have been temporarily occluded both proximally and distally, this would have been the procedure of choice. The continuous thrill and bruit disappeared when these sutures were tied, but pulsation in the large aneurysm persisted. Pressure on the external iliac artery above the aneurysm obliterated this pulsation, while pressure on the internal iliac artery had no effect on it. The external iliac artery was therefore ligated above the aneurysm but not below it, for it was feared that the latter procedure might seriously interfere with the supply of blood to the extremity, since the inferior epigastric and deep circumflex iliac branches would have been included in the obstructed area. However, since the blood supply to the extremity remained entirely adequate, it is improbable that obstruction of these two arteries would have caused more than transient ischemia. The plan was to produce shrinkage of the aneurysm by proximal obstruction of the artery and then excise the aneurysm at a second operation, but the patient refused to be operated on again. It has not been possible to examine this patient since she left the hospital, but her local physician states that there is now, fourteen months later, little demonstrable difference in the extremities. Swelling, which was marked preoperatively, is no longer present. The condition of the aneurysm is not known.

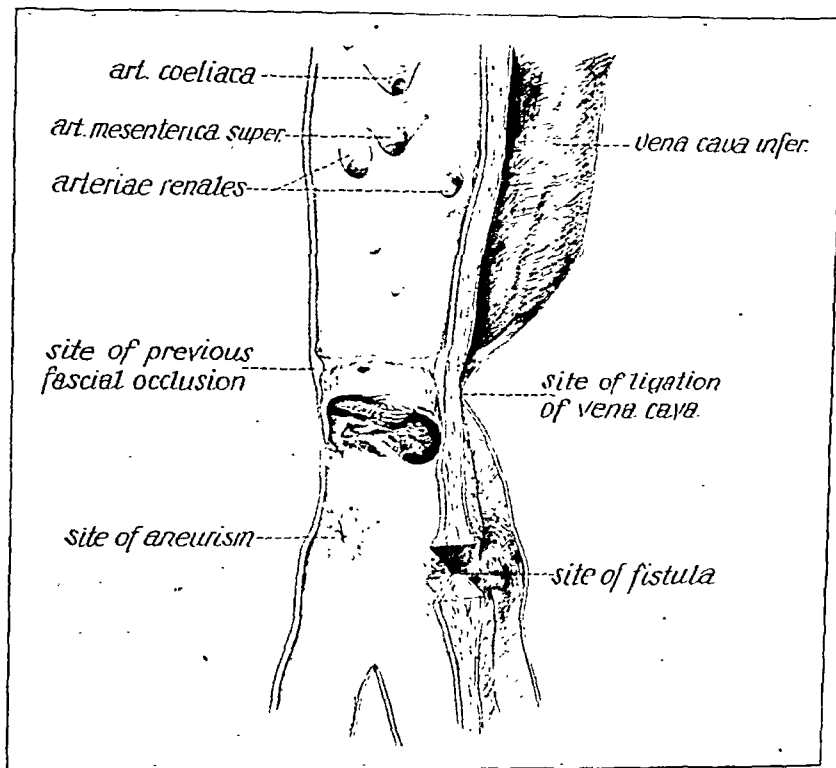
With patient 2 the obvious mistake was the use of tape rather than fascia to occlude the aorta.

Had fascia been used this patient should have survived with the fistula closed and with eventual reopening of the lumen of the aorta. The blind repair of the fistula was justifiable because of the difficulty encountered in isolating the vessels, and this would have been necessary so as temporarily to obstruct them for repair under direct vision.

With patient 3 it was felt that an extensive dissection in the attempt to find the fistula was unjustifiable, as the involved vessels were small and the fistula was of short duration and would probably close after proximal occlusion of both vessels. This apparently occurred.

## COMMENT

The treatment of a traumatic arterial aneurysm does not differ in principle from the treatment of a spontaneous aneurysm when important vessels of the neck and extremities are involved. The goal to be achieved in both is cure of the aneurysm with minimum interference with the supply of blood to the tissues beyond the lesion. Since traumatic aneurysms are more likely to occur in young, active persons whose blood vessels are otherwise normal, the immediate problems of repair are less difficult, and the reactivity of the vessels means less danger of acute insufficiency of blood supply distal to the lesion.



Drawing of the aorta and vena cava from case 2, table 5, showing the site at which the tape cut through. The drawing also shows healing at the site of the aneurysm and the arteriovenous fistula.

In the case of patient 4 the plan was to bring about shrinkage of the false aneurysmal sac so as more safely to expose the bifurcation of the carotid artery at a second operation and thus gain control of the circulation before attempting to repair the fistula. At the same time the collateral circulation was tested and proved adequate. If excision of the fistulous area had become necessary there would have been no fear that this would cause serious cerebral anemia. The fistula closed, the aneurysm was cured and the carotid artery is now patent throughout. This result was as unexpected as it was satisfactory.

On the other hand, it is more important to maintain normal blood supply in young persons than in persons with generalized vascular disease, which is so frequently present in patients who have spontaneous aneurysms.

Therefore, in young men with traumatic vascular lesions of important blood vessels the surgeon not only must give thought to the cure of the lesion and to the prevention of acute ischemia and gangrene but must also consider the late effects on the blood supply to the part. In the literature dealing with the treatment of such lesions much is said, and properly, about the cure of the lesion and the avoidance of acute

ischemia and gangrene, but remarkably little consideration is given to the permanent reduction of blood supply to the tissues, especially the muscles, distal to the lesion.

Makins<sup>3</sup> in his Bradshaw Lecture discussed this problem and stated that Frisch examined 10 patients in whom the main arteries to extremities had been tied from one to eight years previously. In only 4 of the 10 could the limbs be considered sound, while in the remaining 6 there were trophic changes of varying degree. Makins also referred to work done by Karotkoff, who estimated the peripheral blood pressure in 17 patients in whom main arteries had been ligated. In 7 the pressure was less than one-half that in the sound limb, in 4, about one-half and in 4 more than one-half; in only 2 was the pressure equal to that in the sound limb.

Of the patients reported on in this paper there were 3, patient 3 in table 2 and patients 3 and 4 in table 3, in whom the common femoral artery was permanently occluded and 1, number 1 in table 5, in whom the external iliac artery was ligated. In 2 of these patients, both of whom had the vessels ligated and resected for arteriovenous fistulas, the involved extremity now tires quickly, especially on rapid walking or walking up hill. The third patient had the fistula closed by suture, the artery ligated proximally, and the vein ligated both proximally and distally. This patient also states that the affected leg tires rapidly. The fourth patient, a 14 year old boy, apparently has few symptoms of circulatory deficiency in the involved extremity at the time of writing, eight months after the operation. It may be significant that this boy had a chemical (alcohol) section of the lumbar sympathetic nerves. Gage and Ochsner<sup>4</sup> have shown that this procedure is of great value in the prevention of ischemic gangrene. It may be that when the main artery to an extremity is ligated sympathetomy will also prevent the chronic circulatory deficiency so frequently encountered under such circumstances. Another factor which may have played a part in the good functional result in this boy is the preservation of collateral channels by the use of aneurysmorrhaphy.

Two patients who had resection of the popliteal vessels for arteriovenous fistula have serious disturbance of the circulation in the involved extremities. One has had recurrent ulcers of the leg, and the other is now a patient in an army

hospital awaiting discharge from the army because of inadequate circulation in the affected leg. Of the 3 patients in whom the superficial femoral artery was occluded a late follow-up has been possible with only 1. This patient states that the involved leg tires more quickly than the other leg and that he suffers constantly from coldness of the foot.

With an arterial aneurysm there is only moderate danger of gangrene if operation is delayed until the collateral circulation has been established, even though the sac is completely excised and collateral channels are thereby sacrificed. For a traumatic aneurysm with associated lesions of important nerves, excision of the aneurysmal sac is indicated, for this procedure permits *examination and repair of the injured nerves*; but when there is no especial indication for excision of the sac and no contraindication to aneurysmorrhaphy the latter is the operation of choice. When restorative aneurysmorrhaphy is possible, cure may be obtained with little interference with the circulation, and even when obliterative aneurysmorrhaphy is performed the distal circulation is disturbed less than when the sac is excised, because fewer collateral channels are sacrificed. The simplicity of the Matas operation and the saving of collateral channels are important advantages.

In a patient with an arteriovenous fistula a remarkable collateral circulatory bed develops and there is little danger of ischemic gangrene after resection of a main artery, even the common femoral or popliteal, but such a patient appears to be as prone to chronic circulatory difficulty as one having ligation of a corresponding vessel for arterial aneurysm. In the patients here reported on in whom a main vessel was resected for arteriovenous fistula there was no instance of serious acute circulatory difficulty, but all of them have evidence of persistent circulatory deficiency.

In spite of this undesirable effect, it seems to be the consensus of most writers that ligation of the artery and the vein and excision of the fistulous area is the procedure of choice in the treatment of an arteriovenous fistula, and Elkin and Woodhall made the following statement: "Moreover, the eradication of an arteriovenous fistula is accomplished only by quadruple ligation and excision. Any other method usually results in recurrence."

There is no doubt that quadruple ligation and excision result in the highest percentage of cures. However, in properly selected cases the Matas operation, proximal and distal ligation of the vein plus transvenous repair of the artery, under

3. Makins, G. H.: The Bradshaw Lecture: Gun-shot Injuries of the Arteries, London, Oxford University Press, 1914.

4. Gage, M., and Ochsner, A.: Ann. Surg. **112**: 938 (Nov.) 1940.

direct vision, will cure a high percentage of patients with minimum disturbance of the circulation.

#### SUMMARY

Twenty-nine cases of traumatic arterial aneurysm or arteriovenous fistula have been studied. Unfortunately, satisfactory follow-up studies have not been possible in a considerable number of cases but it is believed that evidence of some value has been obtained regarding the occurrence of subjective symptoms of chronic circulatory deficiency after obstruction of main arteries of the extremities. Eight of 9 patients in whom one of the main arteries to the lower extremity was obstructed had follow-up examinations at periods of from nine months to eight years after operation. Seven of them have definite symptoms of chronic circulatory deficiency distal to the obstruction.

Excision of an aneurysmal sac is more certain to cure the lesion than aneurysmorrhaphy but has the disadvantage of destroying more collateral channels than does the intrasaccular operation. It is reasonable to assume that interference with the collateral arteries would increase the danger of ischemic gangrene and would also increase the degree of chronic circulatory deficiency.

An atypical or incomplete operation may result in cure of a traumatic aneurysm, but an arteriovenous fistula is rarely cured except by complete ligation of the involved vessels and excision of the fistulous area or by suture of the artery. If the latter procedure is employed it is usually better to ligate the vein above and below the fistula and then to open the vein and suture the artery under direct vision.

Evidence is also presented which indicates that while the excellent collateral circulation developed in the presence of an arteriovenous fistula makes the danger of ischemic gangrene almost negligible, it does not prevent persistent circulatory difficulty when main vessels are ligated and resected. It is therefore suggested that when such important vessels as the carotid artery and jugular vein, the common femoral vessels or the popliteal vessels are the site of arteriovenous fistula transvenous repair of the artery be employed if there are no contraindications. The most important contraindication to arterial suture is calcification of the wall of the artery in the area to be sutured.

When main vessels are obstructed, especially those to the lower extremity, permanent interruption of the sympathetic nerves to that extremity may help prevent chronic circulatory deficiency distal to the obstruction.

#### ABSTRACT OF DISCUSSION

DR. JOHN DEJ. PEMBERTON, Rochester, Minn.: In many cases it is essential that preliminary measures be undertaken before the blood flow of a main artery is interrupted. These measures are directed toward (1) enlarging the capacity of the secondary channels by prolonged intermittent compression of the artery proximal to the site of the aneurysm (Matas) or by partial compression of the artery by means of bands and (2) reducing the peripheral resistance to blood flow by means of sympathectomy. For an arteriovenous fistula of at least several months' duration, these preoperative measures are seldom necessary, because the presence of the arterial fistula, as was pointed out by Mont Reid, serves as a powerful stimulant to the development of collateral circulation. In addition to preliminary measures, another measure is sometimes needed in order to maintain the collateral circulation, that is, the use of anticoagulants to prevent the formation or propagation of a clot in the artery distal to the point of blockage. With the possible exception of fistulas involving the carotid artery and the cavernous sinus, the complete occlusion of the internal carotid artery in the neck is always fraught with two principal dangers: (1) anemia of the brain due to inadequate collateral circulation, arising perhaps from anomalies of the circle of Willis, and (2) secondary thrombosis or embolism in the distal segment of the carotid artery and its branches. Cerebral disturbances due to cerebral anemia become manifest immediately after the occlusion of the artery, whereas in cases of thrombosis there is an interval of hours or even days between the operation and the manifestation of the cerebral disturbances. The cause of the clotting is probably a combination of factors—stagnation of blood in the distal segment of the carotid artery and injury of the intima at the site of occlusion. This complication was first impressed on me in 1933, when I operated on a woman 39 years of age for a malignant tumor of the left carotid body, which had infiltrated into the surrounding tissues and onto the walls of the internal and external carotid arteries. To remove the tumor it was necessary to excise segments of the common, external and internal carotid arteries. The postoperative course was satisfactory for forty hours; then hemiplegia developed, and the patient was unable to speak or swallow. Bronchopneumonia supervened, and she died on the sixth postoperative day. Necropsy revealed thrombosis extending into the left middle cerebral artery with infarction of the left parietal lobe of the brain. Since then this complication has occurred in 2 other patients in my service, but with happier results. One was a man 21 years of age who was operated on Jan. 29, 1943 for a tumor of the left carotid body. Exposure revealed a large (4 by 3 by 3 cm.), firm, infiltrating tumor which was adherent to the surrounding structures, including the walls of the carotid arteries. After examining a specimen removed from the tumor the pathologist reported a malignant tumor of the carotid body. The tumor then was excised, together with segments of the external, internal and common carotid arteries. Twelve hours later the patient seemed drowsy and the movements of the right arm and leg were less than those of the left side. The movements of his eyes were normal. Intravenous administration of heparin was started immediately, and 300 mg. of dicoumarin (3,3'-methylenebis-[4-hydroxycoumarin]) was administered by means of an intranasal tube. On the third postoperative day the prothrombin time was estimated to be seventy-one seconds and the administration of heparin was stopped. The administration of

dicoumarin was continued in doses sufficient to maintain the prothrombin time at more than thirty-five seconds, as determined by daily estimations, for two weeks. On the fourth postoperative day the patient was able to swallow and his state of consciousness was practically normal. He, however, was unable to speak, although he seemed to understand the spoken word. General improvement continued, and when he was dismissed from the clinic on the twenty-seventh day his right arm was still partially paralyzed and he was able to say only a few words. Six months later examination revealed remarkable improvement, but he still had slight difficulty in speech and slight weakness in his right hand. The second patient was a man 43 years of age, who was operated on Oct. 30, 1942 for a fusiform aneurysm of the first portion of the right internal carotid artery, which measured about 3.5 by 2 by 2 cm. As a preliminary procedure the common carotid artery was partially compressed by a fascial band and the external carotid artery was ligated. Convalescence was normal. The patient returned four months later for the second procedure. About ten hours prior to an obliterative endoaneurysmorrhaphy he was given 300 mg. of dicoumarin. Convalescence was satisfactory for about twenty-two hours, after which time he suddenly complained of loss of sight in his right eye. The pupil did not react to light, and examination of the fundus revealed closure of the central retinal artery, with considerable narrowing of all its branches. Administration of heparin was started, and treatment with dicoumarin was continued. On the third postoperative day examination revealed good blood flow through many of the retinal arteries and all the veins and improvement in the patient's vision. At the time of the patient's dismissal, about two weeks after operation, vision in his right eye was about 40 per

cent. It is my belief that extensive thrombosis was prevented in both patients by the use of anticoagulants and that thrombosis could probably have been prevented altogether if heparin had been administered immediately at the conclusion of the operation. I am convinced that the administration of anticoagulants is definitely indicated in all cases in which operative occlusion of the internal or common carotid artery has been performed and perhaps also in cases in which other main arteries are involved. Such anticoagulant therapy is especially needed in cases in which the sufficiency of the collateral circulation is in doubt. These drugs should be so administered that their full anticoagulant value will be effective immediately after the operation and will be maintained for ten to twelve days thereafter.

DR. WALLER OVERTON BULLOCK, Lexington, Ky.: The subject is "traumatic aneurysms." I wish to say that pulsating hematoma, false aneurysms and true aneurysms are all the same. The only difference is in time. It is my view that a traumatic aneurysm is a clot with a cavity in it, lined with endothelium and connected with a blood vessel, a result of injury. The essential thing in the treatment of this condition is to discover it as early as possible, not to wait until the aneurysm develops. In the early stages the pulsating tumor in a wound and extravasation will be present. When these are noted repair work should be done immediately, before the aneurysm develops. The bruit and other characteristic sounds may not appear until later. Many aneurysms can be prevented in the future by early attention to the symptoms that are the result of injuries to the vessels and by immediate repair.

DR. I. A. BIGGER, Richmond, Va.: [In closing the discussion Dr. Bigger emphasized some of the points in his summary.]



## SURGICAL TREATMENT OF HYPERTENSION

THE EFFECT OF RADICAL (LUMBODORSAL) SPLANCHNICECTOMY ON THE HYPERTENSIVE STATE OF ONE HUNDRED AND FIFTY-SIX PATIENTS FOLLOWED ONE TO FIVE YEARS

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The series of 156 hypertensive patients whose cases are considered in this paper were operated on during the past five years and followed for one to five years. The preoperative resting diastolic blood pressure levels ranged from 100 to 162 mm. of mercury. There were 92 women and 64 men. The average age of the women was 35 and of the men 40 and of the entire series 37. The ages ranged from 16 to 57 years.

Included are 11 patients with pyelonephritis<sup>1</sup> and 1 with polycystic kidneys. They have done unusually well. Three patients with adrenal tumors,<sup>2</sup> cortical or medullary, which in retrospect appeared to be dominant factors in the hypertensive state are excluded. On the other hand, 6 patients with adrenal tumors which did not appear to have been of major importance are included. All of these had cortical adenomas, which, like all of the tumors, were unexpectedly found at operation. In some of the cases of pyelonephritis also the condition was found at operation, and the polycystic kidneys previously mentioned were likewise detected in this way. None of the patients with adrenal tumors had paroxysmal hypertension. This series, then, aside from these exceptions, is largely composed of patients with hypertension of all degrees of severity without known primary disorders of the kidneys or adrenal glands. One can, however, gather an approximate idea of the possible incidence of such disorders in a group of hypertensive patients of this size.

The operation, lumbodorsal splanchnicectomy,<sup>3</sup> is more extensive than other operations<sup>4</sup> which

have been performed for the relief of hypertension with the exception of the total or near-total sympathectomy of Grimson.<sup>5</sup> Its purpose is insure a thorough denervation of the visceral vascular bed. A study of the possible origin of the vasomotor nerve supply to this area in man indicates that it is diffuse. Potentially important pathways may arise from the sympathetic trunks from the third dorsal to the second lumbar segment inclusive and reach the splanchnic bed in a manner which varies considerably from patient to patient and even on the two sides of the same patient. It was clearly demonstrated by multiple stage operations on hypertensive patients that failure to modify the hypertension in a given patient could be due to inadequate surgical operation.<sup>3</sup> A failure to decrease the hypertension following a lesser operative procedure can be converted into a successful result by removing more extensive portions of the sympathetic trunks in subsequent stages.<sup>3</sup> Similar experiences were reported by deTakáts and his associates<sup>6</sup> and by Ayman and Goldshine.<sup>7</sup> It was also demonstrated that near-total sympathectomy could fail to modify the hypertensive state significantly.<sup>3</sup>

Since these pathways arise both above and below the diaphragm, a transdiaphragmatic approach was used in this series, the inner portions of the eleventh and twelfth ribs being resected through a paravertebral incision. In all cases

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1. These patients together with others will be reported on separately as well.

2. These patients together with 1 other will be reported on separately.

3. Smithwick, R. H.: A Technique for Splanchnic Resection for Hypertension, *Surgery* 1:1-8, 1940.

4. Adson, A. W., and Brown, G. E.: Malignant Hypertension: Report of Case Treated by Bilateral Section of Anterior Spinal Nerve Roots from the Sixth Thoracic to the Second Lumbar, Inclusive, *J. A. M. A.*

102:1115-1118 (April 7) 1934. Craig, W. M.: Surgical Approach to and Resection of the Splanchnic Nerves for Relief of Hypertension and Abdominal Pain, *West. J. Surg.* 42:146-152, 1934. Peet, M. M.: Splanchnic Section for Hypertension: A Preliminary Report, *Univ. Hosp. Bull., Ann Arbor* 1:17-18, 1935. Crile, G.: Genesis and Surgical Treatment of Essential Hypertension, *Pennsylvania M. J.* 40:1017-1020, 1937.

5. Grimson, K. S.: Total Thoracic and Partial Total Lumbar Sympathectomy and Celiac Gangliectomy in Treatment of Hypertension, *Ann. Surg.* 114:753-775, 1941.

6. deTakáts, G.; Heyer, H. E., and Keeton, R. W.: The Surgical Approach to Hypertension, *J. A. M. A.* 118:501-507 (Feb. 14) 1942.

7. Ayman, D., and Goldshine, A. D.: Blood-Pressure Determinations in Patients with Essential Hypertension, *New England J. Med.* 229:799-811, 1943.

the great splanchnic nerves were removed from the semilunar ganglion to the midthoracic level or higher. Various portions of the sympathetic trunks were excised. The minimal operation included removal of the tenth thoracic to the first lumbar ganglions inclusive, and the maximal, excision of the sixth thoracic to the third lumbar ganglions inclusive. When the second lumbar ganglions are removed, the lower extremities are denervated as well. If only the first lumbar ganglions are removed, the effect on the legs varies from practically no inactivation to complete or nearly complete inactivation of sympathetic control. This operation was performed in two stages. The operative mortality was 2.8 per cent. For the present, these variations in extent of operation have been disregarded in the discussion of the effect on blood pressure. Even-

TABLE 1.—Effects of Lumbodorsal Splanchnicectomy on the Blood Pressure of One Hundred and Fifty-Six Patients Followed From One to Five Years\*

Result, Group†	No. of Patients	Percentage	Effects of Lumbodorsal Splanchnicectomy	
			Effect on Diastolic Blood Pressure	Average Reduction
1	64	41.0	Lowered 30 mm. or more	61/43
2	32	20.5		
3	28	17.9		
4	17	10.9	Lowered 0 to 9 mm.	10/5
5	15	9.7	Increased	(increase) 18/11
Total	156			

\* Average time followed, twenty-two and a half months.

† In this table the results are considered as a whole. They have been subdivided into six smaller groups according to type of blood pressure and sex (tables 2, 3 and 4). When subdivided in this fashion, the results are much more helpful in indicating the outlook for the individual patient than when they are undivided, as in this table.

ually, when the series is larger, the patients will be divided into groups according to the magnitude of operation. Anatomic factors as well as the technic of operation have been previously described.<sup>8</sup> Surgical technic, physiologic effects, complications and mortality will be discussed in greater detail in a future communication.

#### EFFECT OF OPERATION ON BLOOD PRESSURE

The results have been divided into five groups, according to the magnitude of the effect on the horizontal resting diastolic blood pressure level (table 1). In group 1 there was a lowering of 30 mm. or more; in group 2, of 20 to 29 mm.; in group 3, of 10 to 20 mm., and in group 4, up

to 10 mm.; in group 5 the blood pressure was higher. The average reduction for the first four groups was 61/43, 44/24, 27/15 and 10/5 mm. respectively. In group 5 the average elevation was 18/11 mm. The results for 61.5 per cent of the patients fell into groups 1 and 2, those for 79.4 per cent, into groups 1, 2 and 3 and those for 20.6 per cent into groups 4 and 5. The results of groups 1 and 2 are regarded as significant and of group 3 as probably significant. The 156 patients have been followed an average of twenty-two and one-half months. Two thirds of the patients have been followed an average of seventeen months and one third an average of thirty-five months. There is no important difference in the results in these two groups of patients. A further period of observation is needed to determine the duration of the effect of operation. White and associates<sup>9</sup> judged the effect of operation by comparing the blood pressure before and after operation for 100 of the patients included in this series. The purpose of their analysis was to contrast the effect of lumbodorsal splanchnicectomy with that of nonspecific operations on the blood pressure of hypertensive patients; there was a great difference in favor of splanchnicectomy.

#### METHOD OF STUDY

The effect of operation has been judged by the change in the horizontal resting diastolic blood pressure. In evaluating the blood pressure of hypertensive patients one must take into consideration the marked variability which is characteristic of hypertension in man. In judging the effect of any form of treatment observations should be made under comparable conditions. Lower levels of blood pressure occur when patients are at rest and higher levels when patients are up and about, subjected to the trials and tribulations and the stresses and strains of life. It is surprising at times to find the resting levels within the normal range, when the levels which are determined in the office or clinic are high. This occasionally may be the case for patients with advanced retinal changes, electrocardiographic changes and severe degrees of arteriolar disease, as judged by renal biopsy, especially in the earlier stages of the disorder, before vascular damage of consequence is evident. Thus, the so-called transient or nervous hypertension may be an extremely important condition.

The resting level is determined by hospitalizing the patient, as a rule for several days, but occasionally for weeks or months, most of which time is spent in bed. Scattered readings of the blood pressure obtained by different nurses are recorded, as well as the readings taken by a physician on the patient's admission to the hospital. Previous readings taken by the patient's physician

9. Rojas, F.; Smithwick, R. H., and White, P. D.: Nonspecific Major Operations and Lumbodorsal Sympathectomy: A Comparison Between Their Effects on the Blood Pressure *J. A. M. A.* 126:15-17 (Sept. 2) 1944.

8. White, J. C., and Smithwick, R. H.: *The Autonomic Nervous System*, New York, The Macmillan Company, 1941, p. 469. Smithwick.<sup>3</sup>

or at the clinic are available for comparison. At the end of this period a more detailed study of blood pressure is performed by the same trained technician, as I have found that lower levels are obtained in this manner than when readings are taken by different nurses or physicians.

The purpose of such a study is to obtain data for the eventual discussion of factors which affect the tone and the reactivity of smooth muscle and for the immediate discussion of the effect of operation on resting

levels and on higher levels resulting from stimulation of the patient. Cognizance has been taken of the writings of Hines and Brown<sup>10</sup> in particular, who have among other things demonstrated clearly that the unusual variability of blood pressure in these patients is due to hyperreactivity of the vascular bed to stimuli of one sort or another, particularly cold. When the vascular bed is stimulated with the patient in the resting horizontal position, sharp reflex responses can be demonstrated in the majority of hypertensive patients. The

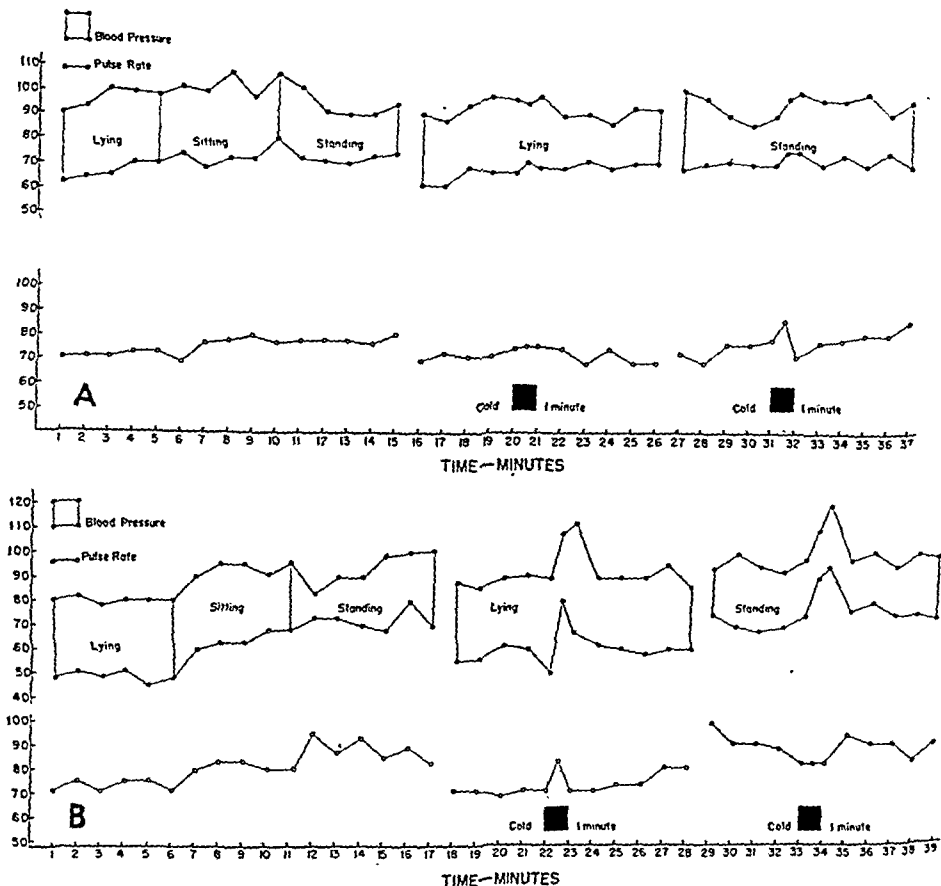


Fig. 1.—A, the reaction of a normal subject to the postural and cold test. In the central portion of the test the reflex response to cold is determined with the subject in the horizontal position. In this patient there was essentially no response. This subject is a hyporeactor, according to the criteria of Hines and Brown, as the response is indicated by a rise in blood pressure of less than 20 mm. systolic and 15 mm. diastolic. They found this to be the case in about 85 per cent of normal subjects. B, the reaction of a normal subject to the postural and cold test. This subject is a hyperreactor to cold when stimulated in the horizontal position. According to Hines and Brown, about 15 per cent of normal subjects react in a similar fashion, the response being a rise of more than 20 mm. systolic and 15 mm. diastolic. They also found that about 95 per cent of hypertensive patients react in this abnormal fashion. Note also the unusually active reflex responses of this person to change of posture and to a cold stimulus when standing (compare with A).

10. Hines, E. A., Jr., and Brown, G. E.: A Standard Stimulus for Measuring Vasomotor Reactions: Its Application in the Study of Hypertension, *Proc. Staff Meet., Mayo Clin.* 7:332-335, 1932; A Standard Test for Measuring the Variability of Blood Pressure: Its Significance as an Index of the Prehypertensive State, *Ann. Int. Med.* 7:209-217, 1933. Hines, E. A., Jr.: Reaction of the Blood Pressure of 400 School Children to a Standard Stimulus, *J. A. M. A.* 108:1249-1250

(April 10) 1937; The Heredity Factor in Essential Hypertension, *Ann. Int. Med.* 11:593-601, 1937; The Significance of Vascular Hyperreaction as Measured by the Cold Pressor Test, *Am. Heart J.* 19:403-416, 1940; The Range of Normal Blood Pressure and Subsequent Development of Hypertension, *J. A. M. A.* 115:371-375 (July 27) 1940; The Background and Treatment of Hypertensive Disease, *South. Med. & Surg.* 103:306, 1941.

reaction of normal persons to stimulation varies from almost none (fig. 1 *A*) to a marked reaction (fig. 1 *B*), in which the reflex responses are similar to and of the same magnitude as those commonly noted in hypertensive patients.

The test (figs. 1 to 8) is a modification of the Hines-Brown cold stimulation test, in which the latter,

bed. After a rest period of fifteen to twenty minutes, readings of blood pressure and pulse rate are taken every minute for five minutes, the patient first lying, then sitting and then standing. The patient then assumes the horizontal position, and readings are continued at one minute intervals for five minutes, followed by stimulation by cold for one minute. The opposite

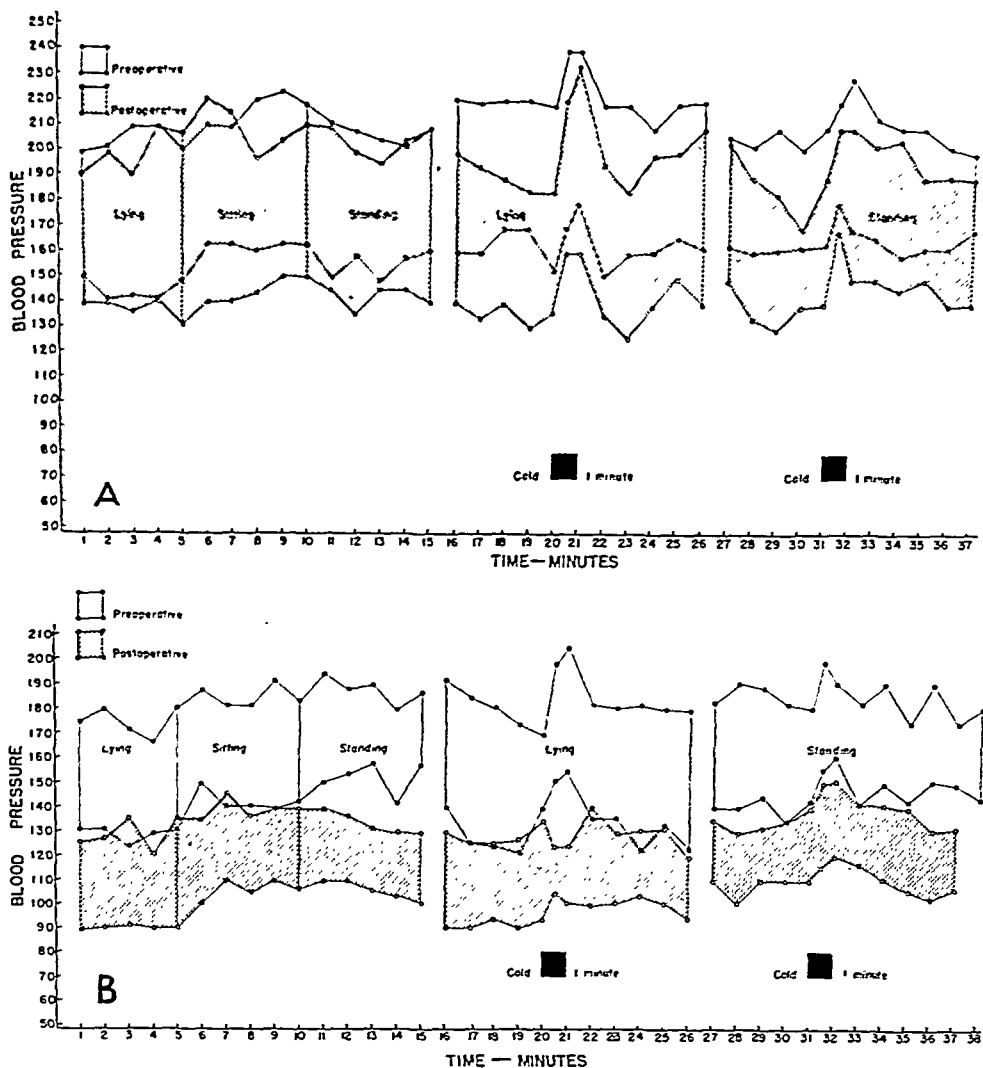


Fig. 2.—Type I hypertension. *A*, a group 4 results. A 30 year old man had grade 4 eyegrounds, early congestive heart failure, poor renal function, a normal nonprotein nitrogen value and a poor response to sedation (table 2). The average preoperative (lying) blood pressure was 203 systolic and 145 diastolic, with a pulse pressure of 58 (one-half the diastolic pressure is 72). The average postoperative (lying) blood pressure was 198 systolic and 136 diastolic. He had a renal biopsy specimen of grade 3. Group 4 and 5 results may occur in patients with grade 0 renal biopsy specimens. *B*, a group 1 result. A 36 year old man had grade 4 eyegrounds, good cardiac and renal functions and excellent response to sedation (table 2). The average preoperative (lying) blood pressure was 175 systolic and 128 diastolic, with a pulse pressure of 53 (one-half the diastolic pressure is 64). The average postoperative (lying) blood pressure was 127 systolic and 90 diastolic. He had a renal biopsy specimen of grade 4.

performed with the patient in the resting horizontal position, is preceded by a simple postural blood pressure test and followed by a repetition of the cold test with the patient in the upright position. Briefly, after several days or more of hospitalization the patient is taken to a quiet pleasant room and placed on a comfortable

hand is immersed in ice water (4 or 5 C.), and readings are taken after thirty seconds and again in one minute, when the hand is removed. Subsequently, readings are continued every minute for five minutes. The cold test is then repeated with the patient in the upright position.

When they are charted, these data give a graphic picture of the approximate nature and magnitude of the hypertensive state of the particular patient. An opportunity exists to compare the effect of operation on the resting horizontal levels as well as on the higher levels resulting from stimulation by change of position or by cold and on the levels noted prior to hospitalization. The 156 patients included in this report had preoperative horizontal resting diastolic blood pressure levels varying from 100 to 162 mm. of mercury. These levels represent the average of the readings taken with the patients in the first posture of the postural and cold test, lying, before change of position. When the series is larger it will be divided into groups of comparable preoperative blood pressure levels. Patients

duration of hypertension is difficult to evaluate because it is rarely accurately dated. The age of the patient, the height of the blood pressure and the response to sedation are all factors to be considered. The response to sedation was determined by administering 3 grains (0.19 Gm. of sodium amytal by mouth at 7, 8 and 9 p. m. Blood pressure and pulse rates were charted hourly from 7 p. m. to 7 a. m. The lowest reading of the blood pressure was taken as the response. The results for 88.5 per cent of those patients in whom the diastolic level fell to 90

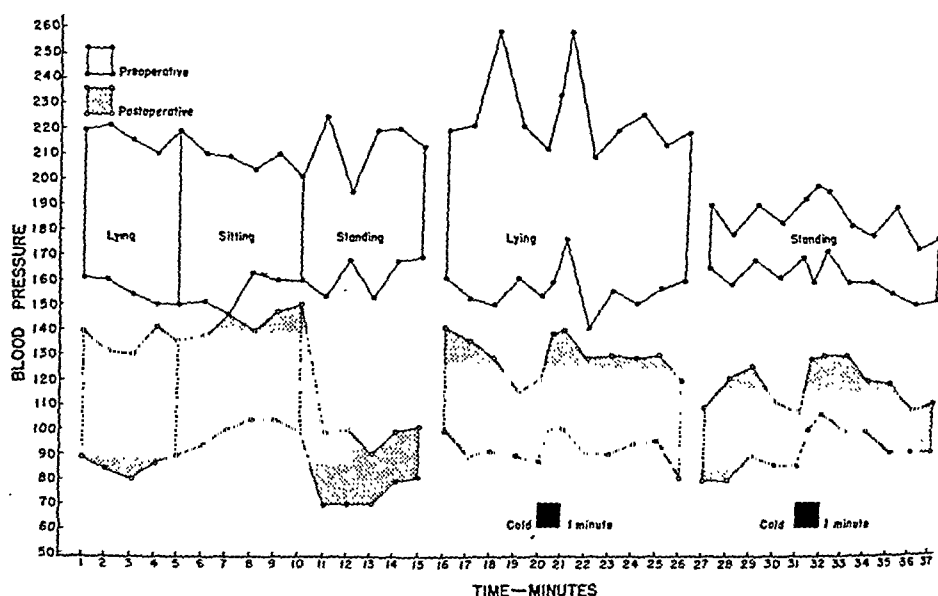


Fig. 3.—Type I hypertension. A group 1 result. A 38 year old man had grade 3 eyegrounds, good cardiac and renal functions, a minor cerebral vascular accident and a fair response to sedation. This chart also illustrates the occasional persistence of asymptomatic postural hypotension one or more years after operation (table 2). The average preoperative (lying) blood pressure level was 217 systolic and 154 diastolic, with a pulse pressure of 63 (one-half the diastolic pressure is 77). The average postoperative (lying) blood pressure was 135 systolic and 85 diastolic. He had a renal biopsy specimen of grade 3.

with resting levels below 100 or within the normal range will be reported on separately. In figures 1 to 8 the readings taken before and after operation are compared, the postoperative chart being cross hatched. The data were obtained in the same fashion except that after operation the patients were ambulatory because of a shortage of beds; consequently they could not be hospitalized for several days before taking the test.

#### FACTORS INFLUENCING RESULTS

It is clear that the effect of operation varies considerably, from no change to a distinct lowering of blood pressure. It therefore is extremely important to determine the circumstances under which the better results may be expected. If one reviews the results with reference to each of many factors, all seem to have some importance, but no single one appears to be all important. The

or less were in groups 1, 2 and 3. The results for 66.7 per cent of those patients in whom the lowest diastolic level was more than 90 were included in groups 1, 2 and 3. This represents a variation of approximately plus or minus 10 per cent from the percentage of patients (79.4) (table 1) whose results without regard to any particular factor fell into groups 1, 2 and 3. The state of the eyegrounds is of importance. The results for 88.5 per cent of the patients with grade 1 eyegrounds, for 77.2 per cent with grade 2, for 69.1 per cent with grade 3 and for 83.3 per cent with grade 4 were classified in groups 1, 2 and 3. Sex is of importance. Women had better results than men. Results for 71.8 per cent of the men and for 84.8 per cent of the women fell into groups 1, 2 and 3.

## TYPES OF HYPERTENSION

A study of the postural and cold test charts has revealed certain important differences in the nature of the hypertensive state, particularly the type of hypertension. This has been judged by

8). Those with wider pulse pressures, equal to or up to 19 mm. more than one-half the diastolic pressure, have type II hypertension (fig. 5). Those with the widest pulse pressures, 20 mm. or more greater than one-half the dia-

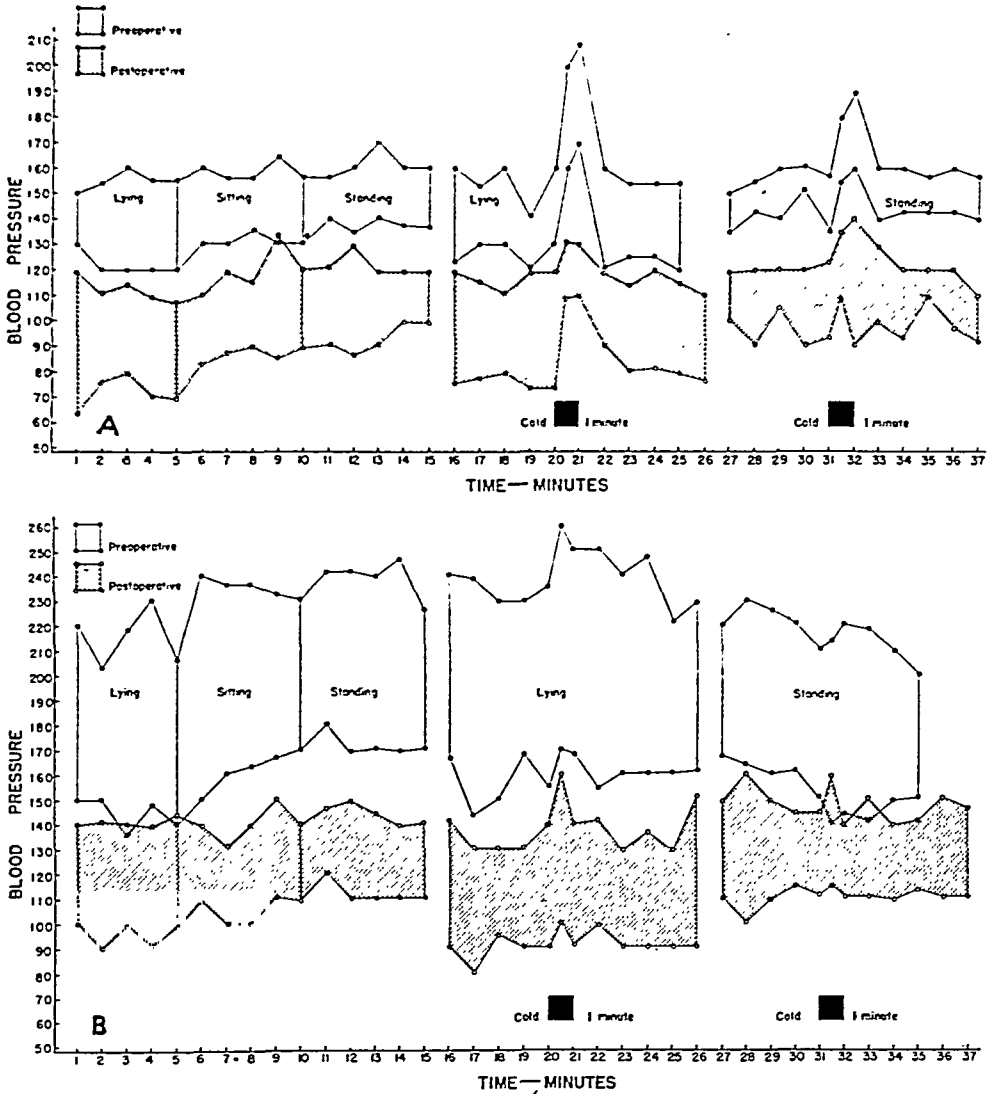


Fig. 4.—Type I hypertension. *A*, a group 1 result. A 16 year old girl had grade 3 eyegrounds, normal cardiac and renal functions and an excellent response to sedation (table 2). The average preoperative (lying) blood pressure was 154 systolic and 122 diastolic, with a pulse pressure of 32 (one-half the diastolic pressure is 61). The average postoperative (lying) blood pressure was 112 systolic and 71 diastolic. She had a renal biopsy specimen of grade 1. *B*, a group 1 result. A 40 year old woman had grade 3 eyegrounds, well marked congestive heart failure, slight impairment of renal function and an excellent response to sedation (table 2). The average preoperative (lying) blood pressure was 215 systolic and 145 diastolic, with a pulse pressure of 70 (one-half the diastolic pressure is 72). The average postoperative (lying) blood pressure was 140 systolic and 95 diastolic. She had a renal biopsy specimen of grade 3.

the width of the pulse pressure with the patient in the resting horizontal position. The patients have been divided into three classes on this basis. Patients with narrow pulse pressures, which are less than one-half the diastolic pressure, have type I hypertension (figs. 2, 3, 4 and

stolic pressure, have type III hypertension (figs. 6 and 7). The result of operation varied with the type, being best for type I and poorest for type III. Eighty-six and five-tenths per cent of the patients with type I, 76.5 per cent with type II and 71 per cent with type III obtained results which were classified in groups 1, 2 and 3.

RESULTS SUBDIVIDED ACCORDING TO  
TYPE AND SEX

The results have been divided into six groups according to the three types and the two sexes

larger, the effect of other factors can be taken into consideration. Clinical examples of three different types of hypertension, the different groups of results in the two sexes, grades of changes in the eyegrounds and re-

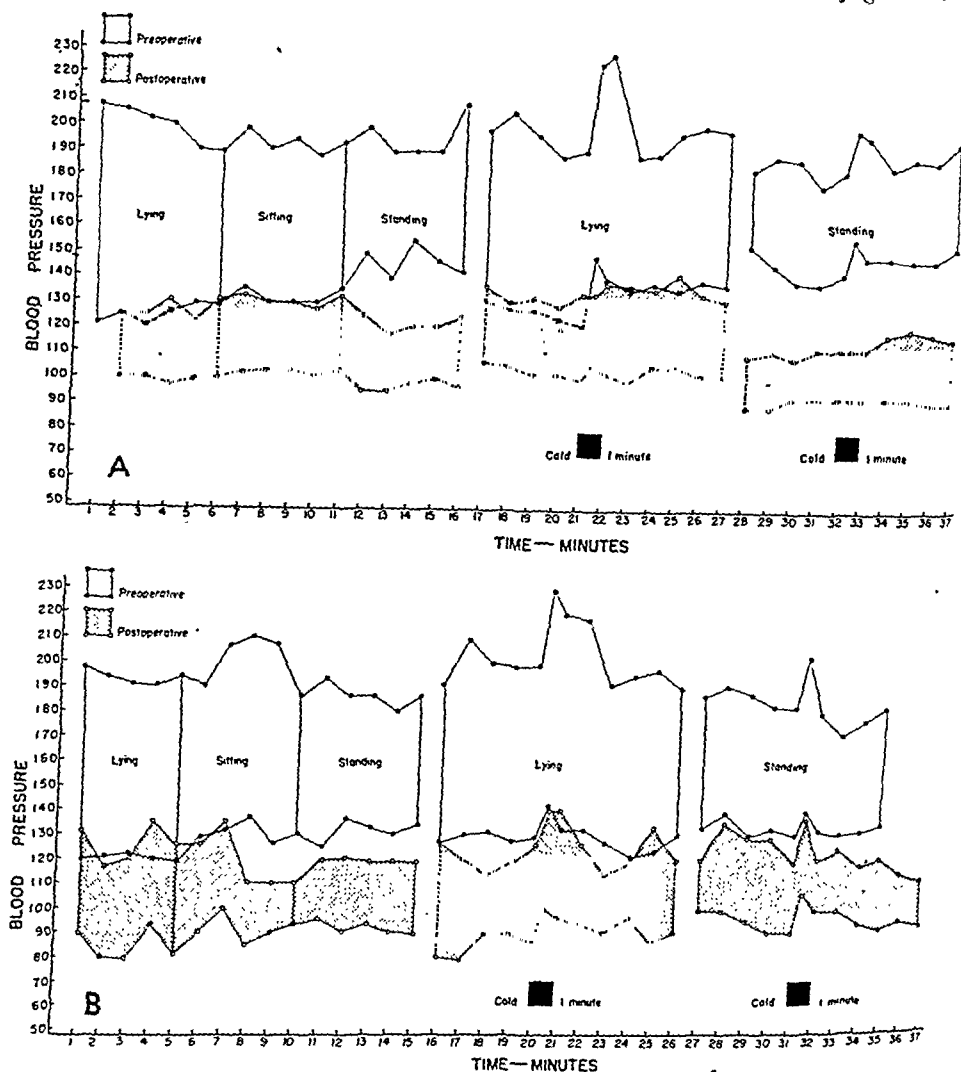


Fig. 5.—Type II hypertension. *A*, a group 2 result. A 50 year old man had grade 4 eyegrounds, mild congestive heart failure, satisfactory renal function and an excellent response to sedation (table 3). The average preoperative (lying) blood pressure was 200 systolic and 125 diastolic, with a pulse pressure of 75 (one-half the diastolic pressure is 62). The average postoperative (lying) blood pressure was 128 systolic and 99 diastolic. He had a renal biopsy specimen of grade 2. *B*, a group 1 result. A 39 year old woman had a severe cerebral vascular accident with partial recovery of function, grade 2 eyegrounds and good cardiac and renal function with a good response to sedation. Six and one-half years prior to a lumbodorsal splanchnicectomy she had undergone a laminectomy with extensive section of the anterior roots, without relief of her hypertension (table 3). The average preoperative (lying) blood pressure was 190 systolic and 120 diastolic, with a pulse pressure of 70 (one-half the diastolic pressure is 60). The average postoperative (lying) blood pressure was 125 systolic and 84 diastolic. She had a renal biopsy specimen of grade 3.

(tables 2, 3 and 4). This necessarily divides such a small series into groups which are not statistically significant. However, such a division seems to cast light on the outlook for the individual patient. When the series becomes

larger, the effect of other factors can be taken into consideration. The postoperative charts were made one to two years after the operation. The best results occurred in women with type I and the poorest in men with type III.

## PYELONEPHRITIS

Eleven of the 156 patients had chronic pyelonephritis. In all but 1 the disorder was bilateral. As indicated in table 5, women predominated, 10 to 2. All types of hypertension were represented, but type I predominated. All grades

TABLE 2.—Hypertension—Type I

Sex	No. of Patients	Result				
		Group 1	Group 2	Group 3	Group 4	Group 5
Men	21	16	5	5	3	5
		61.7%			23.5%	
		78.5%				
Women	33	20	7	5	0	1
		51.5%			3.3%	
		95.8%				

These patients had type I (the most narrow pulse pressure) hypertension, the pulse pressure being less than one half the diastolic pressure. See figures 2, 3, 4 and 5.

TABLE 3.—Hypertension—Type II

Sex	No. of Patients	Result				
		Group 1	Group 2	Group 3	Group 4	Group 5
Men	16	6	2	4	2	2
		59.0%			25.0%	
		73.0%				
Women	25	14	11	2	6	2
		71.4%			22.9%	
		77.1%				

These patients had type II hypertension (a wider pulse pressure), the pulse pressure being equal to or up to 19 mm. more than one half the diastolic pressure. See figure 5.

TABLE 4.—Hypertension—Type III

Sex	No. of Patients	Result				
		Group 1	Group 2	Group 3	Group 4	Group 5
Men	13	1	2	4	4	2
		23.2%			46.2%	
		53.8%				
Women	25	7	5	8	2	3
		47.8%			20.0%	
		80.0%				

These patients had type III (the widest pulse pressure) hypertension, the pulse pressure being 20 mm. or more greater than one half the diastolic pressure. See figures 6 and 7.

changes in the eyeground occurred. As a group these patients did unusually well. The results of 90.1 per cent of these patients fell into groups 1 and 2, and the results of 100 per cent into groups 1, 2 and 3. A clinical example is illustrated in figure 8.

## RENAL BIOPSIES

In a previous communication Castleman and Smithwick<sup>11</sup> reported that the evidence of arteriolar disease in the kidneys of living hypertensive patients, as judged by biopsy material obtained at operation, was considerably less than that obtained by a study of autopsy material. This was thought to indicate that much of the arteriolar disease discovered at autopsy developed as a result of the hypertension. It was also noted that while the great majority of patients did show some evidence of arteriolar damage, in about 50 per cent it was mild, minimal or absent.

TABLE 5.—Pyelonephritis

No. of Patients		Men	Women	Type			Eyegrounds			
				I	II	III	1	2	3	4
11	2	9	7	2	2	3	4	3	1	

Results of Lumbodorsal Splanchnicectomy					
11	Group 1	Group 2	Group 3	Group 4	Group 5
	7	3	1	0	0
	90.1%		100.0%		0.0%

This small series of hypertensive patients with pyelonephritis did unusually well. A clinical example is illustrated in figure 8.

TABLE 6.—Renal Biopsies

Renal Biopsy Specimens, Grade	Biopsy Specimens Taken	Result of Lumbodorsal Splanchnicectomy					No. of Patients
		Group 1	Group 2	Group 3	Group 4	Group 5	
0, 1 and 2	79	24 (42.2%)	9 (15.8%)	13 (22.8%)	3 (5.1%)	8 (14.1%)	57
		58.0%		50.8%			19.2%
3 and 4	75	33 (43.6%)	13 (19.1%)	10 (14.7%)	9 (13.2%)	3 (4.4%)	63
		67.7%		82.4%			17.6%

The effect of operation on blood pressure was essentially the same in the patients with the milder forms of renal arteriolar disease as with the more severe degrees.

These data were obtained from a study of the first 100 consecutive patients for whom biopsy was done. The figures for the present, somewhat larger series are essentially the same. The patients have been divided into two groups according to the grade of the renal changes shown by biopsy (table 6). Those with changes of grades 0, 1 and 2 shown by biopsy (no disease,

11. Castleman, B., and Smithwick, R. H.: The Relation of Vascular Disease to the Hypertensive State. Based on a Study of Renal Biopsies from One Hundred Hypertensive Patients, *J. A. M. A.* **121**:1256-1261 (April 17) 1943.



minimal and mild) have been placed in one group, and those with grades 3 and 4 (more advanced degrees of arteriolar disease) have been placed in the other group. The effect of operation in the two groups has been compared.

In a previous communication, Ta associates<sup>12</sup> determined the amount flowing through the kidneys of 20 patients of whom have been included in this series and at various intervals after operation.

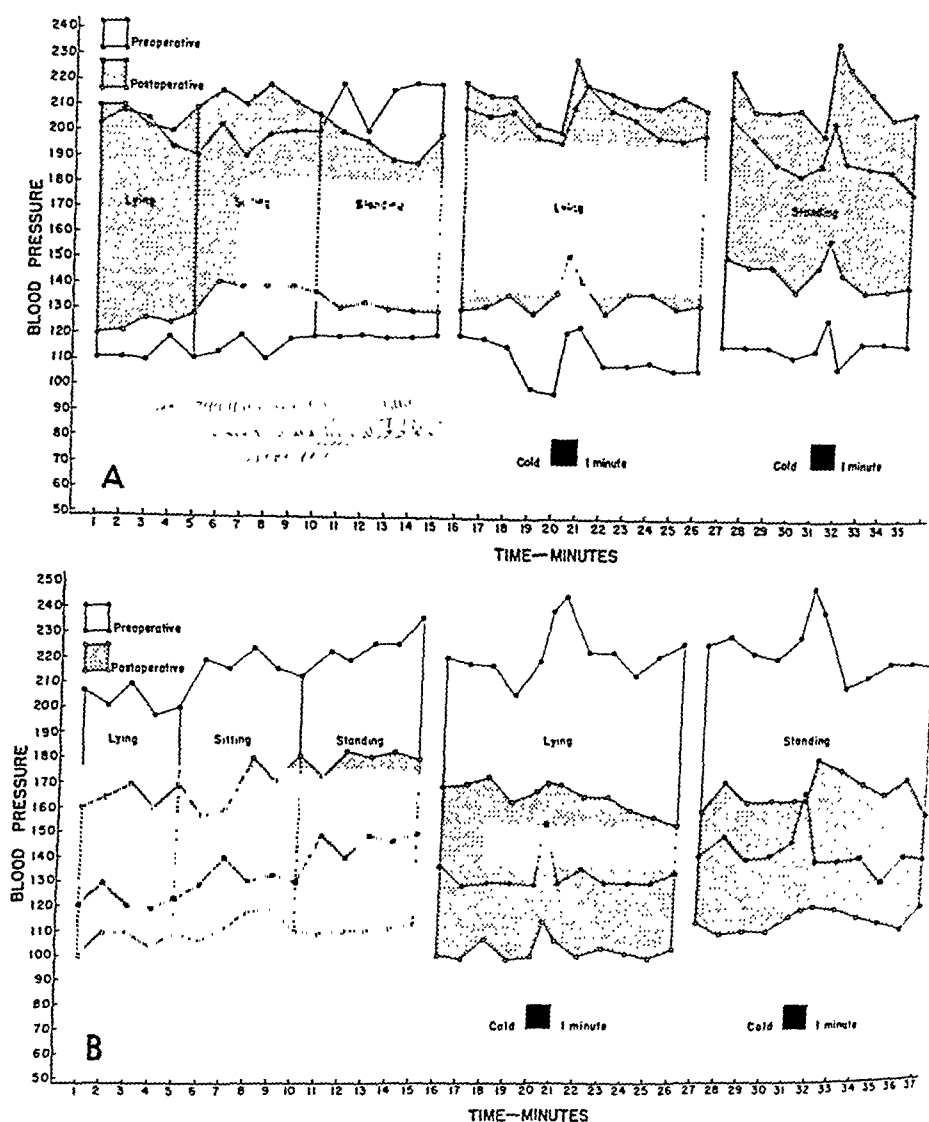


Fig. 6.—Type III hypertension. *A*, a group 5 result. A 48 year old man had grade 3 eyegrounds, impaired congestive heart failure, normal renal function and a poor response to sedation (table 4). The average preoperative (lying) blood pressure was 200 systolic and 112 diastolic, with a pulse pressure of 88 (one-half the diastolic pressure is 56). The average postoperative (lying) blood pressure was 207 systolic and 124 diastolic. He had a renal biopsy specimen of grade 2. *B*, a group 3 result. A 45 year old man had grade 4 eyegrounds, well marked congestive heart failure and slight impairment of renal function, with an excellent response to sedation (table 4). The average preoperative (lying) blood pressure was 202 systolic and 121 diastolic, with a pulse pressure of 81 (one-half the diastolic pressure is 60). The average postoperative (lying) blood pressure was 164 systolic and 105 diastolic. He had a renal biopsy specimen of grade 3.

There is essentially no difference, the percentage of patients with different results as regards blood pressure being practically the same for both the milder and the more severe degrees of renal arteriolar disease.

12. Talbott, J. H.; Castleman, B.; Smithwick, R. H.; Melville, R. S., and Pecora, L. J.: Renal Biopsy Specimens Correlated with Renal Clearance Observations in Hypertensive Patients Treated by Radical Sympathectomy. *J. Clin. Investigation* 22:387-394, 1943.

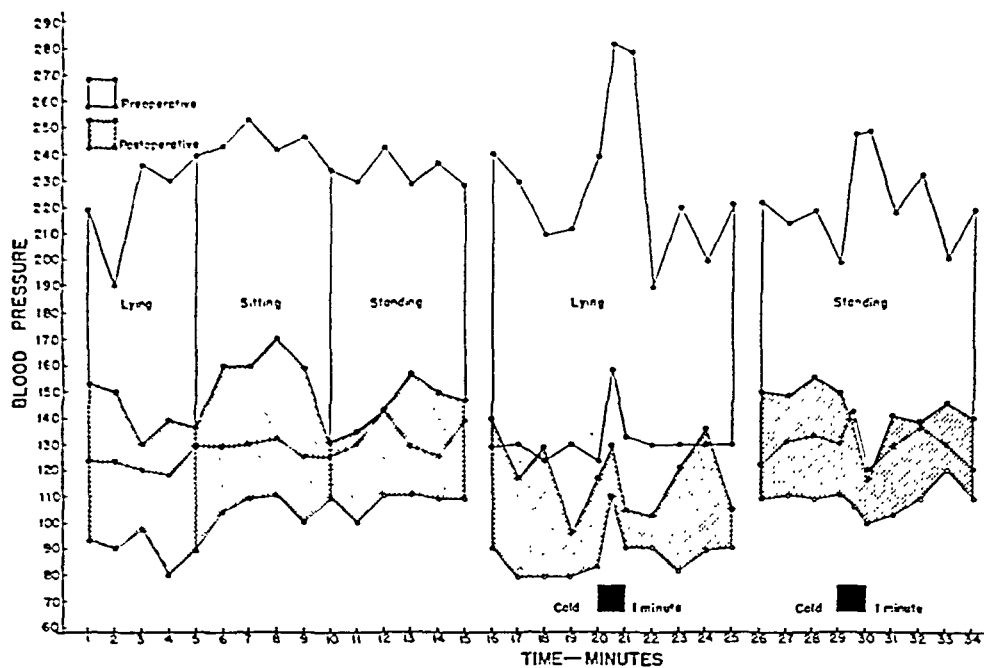


Fig. 7.—Type III hypertension. A group 1 result. A 42 year old woman had grade 3 eyegrounds, satisfactory cardiac and renal functions and a good response to sedation (table 4). The average preoperative (lying) blood pressure was 227 systolic and 123 diastolic with a pulse pressure of 104 (one-half the diastolic pressure is 61.5). The average postoperative (lying) blood pressure was 141 systolic and 89 diastolic. She had a renal biopsy specimen of grade 0.

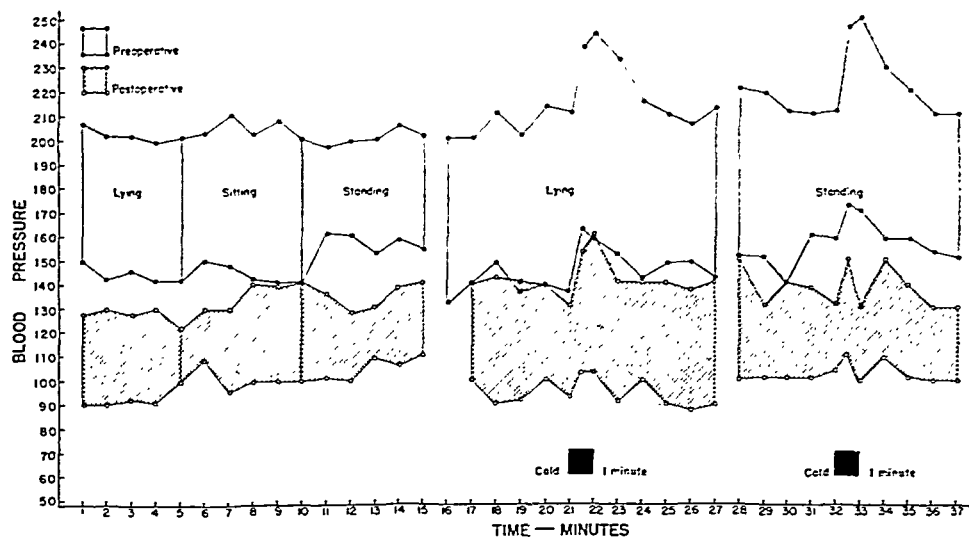


Fig. 8.—Type I hypertension with bilateral chronic pyelonephritis. A group 1 result. A 28 year old woman had grade 4 eyegrounds, moderate reduction of renal function and a fair response to sedation. Two years following operation, this patient had a normal delivery of a normal child. The pregnancy was uneventful, and her hypertension did not recur (table 5). The average preoperative (lying) blood pressure was 202 systolic and 146 diastolic, with a pulse pressure of 56 (one-half the diastolic pressure is 73). The average postoperative (lying) blood pressure was 127 systolic and 93 diastolic. She had a renal biopsy specimen of grade 3.

found: 1. Studies performed on 20 patients with essential hypertension showed a significant correlation between renal clearance and the microscopic appearance of the respective renal tissues which were removed for biopsy at the time of sympathectomy; i. e. the more severe the renal vascular disease, the more reduced were the glomerular filtration rate and the renal blood flow. In the patients with grades 0 and 1 renal biopsy specimens renal clearance was either normal or only slightly reduced. Only in patients with grade 4 renal biopsy specimens was renal blood flow seriously reduced. 2. The filtration fraction was normal in 7 of 8 patients with renal biopsy specimens of grades 0, 1 and 2. It was increased in 6 of 11 patients with grades 3 and 4. These findings indicate that constriction of the efferent glomerular arterioles was not present in the early stages of renal vascular disease. 3. Bilateral radical lumbodorsal splanchnicectomy had relatively little effect on renal clearance, when measured with the patient in the horizontal position. Although glomerular

and exudate as well as all types of vascular changes. Many eyegrounds with blurred margins without measurable elevation were placed in other groups. It is of interest to note that 13 patients with grade 1 eyegrounds had grade 0 eyegrounds after operation. In 19 patients with grade 2 eyegrounds, the arteriovenous compression disappeared completely and in the eyegrounds were graded 0 and in 11 they were graded 1 after operation. In 7 patients with grade 3 eyegrounds and in 2 with grade 4 eyegrounds the eyegrounds were graded 0 after operation. In general, the more advanced the changes in the eyegrounds the higher the percentage of improvement following operation. Lack of progression or improvement was the rule in the great majority of the patients.

ELECTROCARDIOGRAPHIC CHANGES BEFORE AND AFTER OPERATION

Approximately two thirds of the patients had abnormal and one third normal electrocardiograms

TABLE 7.—Effect of Surgical Treatment of Hypertension on Eyegrounds

Preoperative Grade of Eyegrounds Studied	No. of Patients	Postoperative			No. of Patients Followed Up
		Unchanged	Improved	Worse	
0	7	5 (63.3%)	.....	1 (16.7%)	6
1	45	22 (56.4%)	13 (33.3%)	4 (10.3%)	39
2	43	10 (31.2%)	19 (59.3%)	3 (9.5%)	32
3	41	8 (21.7%)	28 (75.7%)	1 (2.6%)	37
4	18	0 (0.0%)	15 (100.0%)	0 (0.0%)	15

TABLE 8.—Effect of Surgical Treatment of Hypertension on Electrocardiograms

Preoperative	No. of Patients Studied	Postoperative			
		No. of Patients Followed Up	Unchanged	Improved	Worse
Within normal limits	52	45	34 (78.5%)	10 (22.2%)	1 (1.7%)
Abnormal.....	99	82	25 (30.6%)	52 (63.5%)	5 (5.9%)
Control series.....	50	50	20 (40%)	5 (10%)	5 (10%)

filtration was reduced in the immediate postoperative period about 20 per cent, within a year it returned to and continued to maintain its preoperative level. Renal flow of plasma was essentially unchanged.

CHANGES IN THE EYEGROUNDS BEFORE AND AFTER OPERATION

Abnormalities of the eyegrounds, varying from grade 1 to 4, were present in all but 7 patients. The details are presented in table 7, together with the changes which occurred following operation. A simple classification was used. Grade 1 includes eyegrounds with any variation from the normal except arteriovenous compression, hemorrhage, exudate and papilledema. Grade 2 includes eyegrounds with arteriovenous compression but without hemorrhage, exudate or papilledema. Grade 3 includes eyegrounds with hemorrhage or exudate or both but without papilledema. Grade 4 includes all eyegrounds with papilledema and measurable elevation of the disks. These generally exhibited hemorrhage

grams before operation (table 8). Of those with abnormal electrocardiograms 63.5 per cent showed slight to striking improvement following operation. The changes in all the patients were interpreted, and in 100 patients of this series they were studied in detail, by White and his associates.<sup>13</sup> These investigators particularly emphasized the pronounced difference in the behavior of the electrocardiograms of patients treated by radical (lumbodorsal) splanchnicectomy and those of patients treated in other ways or untreated. It is of interest to note that even of the electrocardiograms within the wide range of normal, 22.2 per cent approached the more average normal after operation. An unfavorable

13. Evans, E.; Smithwick, R. H., and White, P. D.: Manifestations of Hypertension Reversible by Adequate Splanchnic Resection, with Special Reference to the Electrocardiogram, to be published. Canabal, E. J.; Warneford-Thomson, H. F., and White, P. D.: Electrocardiograms of Hypertensive Patients Followed for a Long Time Without Splanchnic Resection in Comparison with Those Who Had Had Splanchnic Resection, to be published.

change was noted in 1.5 per cent of those with normal electrocardiograms and in 5.9 per cent of those with abnormal records. Generally speaking, the evidence indicates lack of downhill progression or improvement in the great majority of patients following operation. Unfavorable progression was noted in half (25 of 50 patients, or 50 per cent) of the control patients, treated in other ways or untreated. Spontaneous improvement was slight at most and rarely observed in the control patients. Patients having the poorest results as regards blood pressure (groups 4 and 5) who were treated by lumbo-dorsal splanchnicectomy showed a higher percentage of improvement (55.9 per cent) than the control patients (10 per cent) when judged by electrocardiographic changes.

TABLE 9.—*Effect of Surgical Treatment of Hypertension on Renal Function*

Preoperative	No. of Patients Studied	Postoperative			No. of Patients Followed Up
		Unchanged	Improved	Worse	
Albumin 0.....	48	25 (56.3%)	..	4 (13.7%)	29
Albumin +.....	90	18 (30.9%)	40 (69.1%)	0	58
Sediment 0.....	57	27 (96.4%)	..	1 (3.6%)	28
Sediment +.....	77	17 (34.8%)	32 (65.2%)	0	49
I. V. (normal).....	93	74 (95.8%)	..	1 (1.2%)	75
P. S. P. (reduced)....	41	6 (18.1%)	26 (78.0%)	1 (3.3%)	33
Urine concentration					
Normal.....	91	35 (94.7%)	..	2 (5.3%)	37
Reduced.....	42	2 (10.0%)	18 (90.0%)	0	20

#### CHANGES IN RENAL FUNCTION BEFORE AND AFTER OPERATION

The majority of patients had persistent albuminuria and changes in the urinary sediment (table 9). On the other hand, the majority had the ability to concentrate urine to 1.020 or more after withholding fluids for twelve hours. Also, the majority had the capacity to excrete 25 per cent or more of phenolsulfonphthalein, injected intravenously, in fifteen minutes and 55 per cent or more in two hours. None of the patients in this series had persistent evidence of retention of nitrogen, although a few were on the borderline. Disappearance of albuminuria, change to normal in the urinary sediment and improvement in ability to concentrate the urine or ability to excrete the dye were noted in the great majority of patients. An unfavorable

change in any of these functions was extremely rare.

#### COMMENT ON THE RESULTS OF GROUPS 4 AND 5

Favorable changes which were noticed in patients with results in groups 4 and 5 including improved eyegrounds for 48.2 per cent of the patients, improved electrocardiograms for 55.9 per cent and improved renal function for 44.4 per cent, suggest that the progress of the disease may have been arrested and the general condition slightly improved in some of these patients. The necessity of studying the blood pressure after operation with the patients ambulatory and comparing it with the blood pressure of resting hospitalized patients before operation may explain, in part at least, the discrepancy between the result as judged by the effect on blood pressure and as judged in these other ways. As Ayman and Goldshine have clearly shown,<sup>7</sup> the effect of operation on blood pressure when it was determined with the patients ambulatory and judged by a comparison with readings taken at the clinic or office was not significant in certain patients. On the other hand, in these same patients there was a definite lowering of blood pressure following operation, when judged by the blood pressure readings taken at home by the patient or a friend or relative. When favorable changes in the eyegrounds, electrocardiograms, size of the heart or renal function occur after operation, it presumably means that the stress and strain on the vascular bed and the heart have been lessened, most likely because of some favorable effect on the blood pressure, even if the method of study fails to reveal it. I believe that the method of study used in this series tends to understate rather than overstate the results of operation when they are judged solely by the effect on blood pressure levels.

#### SUMMARY

It is apparent that the blood pressure of many hypertensive patients can be significantly lowered by radical surgical intervention on the autonomic nervous system.

In some patients the reflex responses to stimuli were lessened and occasionally abolished. In many patients, however, even when the levels were generally lower, active reflex responses persisted. When the blood pressure is lowered the pulse pressure may decrease, particularly in patients with wider preoperative pulse pressures. A widening of the pulse pressure after operation is unusual.

The results have been judged by the magnitude of the lowering of the diastolic pressure

and on this basis have been divided into five groups.

These results have been further analyzed by dividing them into three types according to the width of the pulse pressure and tabulating them according to sex. Such a subdivision has been helpful in indicating the circumstances under which better results may be expected.

Favorable changes in eyegrounds, electrocardiograms and renal function, together with an improvement in the well-being of the patients, suggest that lowering of blood pressure is not harmful.

The response of patients with pyelonephritis and hypertension to this form of treatment was unusually satisfactory.

There was no significant difference in the results in patients with mild or no renal arteriolar disease as compared with those in patients with more advanced changes.

The effect of operation on blood pressure does not appear to be primarily dependent on the state of the renal arterioles, as judged by biopsy material, or on known renal disease, such as pyelonephritis, when present.

The results strongly suggest that the state of the extrarenal portion of the visceral vascular bed is important and that the lowering of blood pressure following operation may be largely the result of decreased peripheral resistance to blood flow through this area.

Further observation is needed to determine the duration of the effect. One third of these patients have been followed an average of approximately three years and compare favorably with the others, who have been followed approximately one and one-half years. The patients in the series who were treated first are now entering their sixth postoperative year.

It is reasonable to believe that when the series becomes larger it will be possible to take into consideration other factors, so that the outlook for the individual patient who follows this form of treatment can be predicted with greater accuracy.

#### ABSTRACT OF DISCUSSION

DR. E. A. HINES JR., Rochester, Minn.: Dr. Smithwick's data indicate that extensive sympathectomy may profoundly lower the blood pressure in some patients who are suffering from severe degrees of hypertensive disease. This lowering of the blood pressure may persist for months or even years. It is not evident yet, as Dr. Smithwick has stated, whether a more extensive sympathectomy produces a more permanent result than a less extensive operation. For those who believe that sympathectomy has a place in the treatment of hypertension—and I am one of them—one of the vexing problems has been the accurate identification of those

patients who will obtain a good result. The methods of study of reactions and responses of pressure have not answered this adequately. Dr. Smithwick has presented another measuring stick, the width of the pulse pressure, and it is hoped that this will considerably to the knowledge necessary for selecting the patients with hypertension who should be operated on.

DR. GEZA DE TAKATS, Chicago: Dr. Smithwick has been modest about describing the various difficulties of the technic of splanchnic section. He has finally described a type of operation which has been eminently successful. It was necessary for him to try out a number of extensive splanchnic sections before he arrived at the present method, and ever since he published this paper I have followed his technic, since the previous methods did not give such satisfactory results. In his paper he has presented the second phase of the procedure. He has also emphasized that there probably will be a single test or a single criterion for indicating the advisability of operation. It will be necessary to take into consideration a number of factors. In my work I have roughly recognized three groups of patients who come for operation. One group of patients have the early juvenile type of hypertension with minimal detectable organic changes and with complete response to sedation; for this group I feel that radical sympathectomy has offered during the period of observation which now goes back five or six years, excellent results.

There is another group for whom I feel that splanchnic section is not indicated. These patients are in the late stage of the disease: the malignant phase or the late benign phase of hypertension with rigid renal arteries. This condition is best expressed by the fact that Dr. Smithwick has just shown, the large pulse pressure. There is, however, the intermediate group of patients, with a mixture of organic and functional pathologic conditions. I have had my best results in the postclimatic or post-toxic type of hypertension in women who obviously had organic vascular disease. I have also seen good results with the latent nephritic type of hypertension; however, this type has been recognized only after renal biopsy, since clinically it belongs to the essential type.

The mechanism of relief which is obtained by section of the splanchnic nerve should be studied in the future. It is generally agreed now that there is no detectable change in renal function, that the relief of splanchnic vasoconstriction is an important point, that adrenal denervation should not be forgotten, and should also not be forgotten that there are various vascular depots in the splanchnic area, as in the liver and the spleen, which do not function as depots after splanchnic section. There are many factors involved which are not understood and which the physiologist has not cleared up. Until an effective drug or procedure is found splanchnicectomies will have to be done in selected cases.

DR. N. S. DAVIS, Chicago: Sympathectomy paralyzes the renal arterioles and prevents the ischemia caused by the hypertension but does not eliminate the cause of the altered renal cellular chemistry, deamination and decarboxylation with the formation of pressor amines. It prevents extension of the process and permits reversal by limiting the ischemia but does not prevent the development of pathologic cellular anatomy caused by the pathologic cellular chemistry. Sympathectomy must therefore be considered a palliative procedure which at times has distressing side effects.

DR. ROY W. SCOTT, Cleveland: In 68 cases Dr. Smithwick found severe vascular disease even in

small section of the kidney removed at operation; this means of course that probably the entire vascular system of the kidney was involved. In 57 cases he found less severe vascular disease, and in 7 per cent of his first 10 cases in which biopsy was made no vascular disease was found. Before concluding, as Smithwick does, at his findings in this smaller group of 57 cases are in keeping with the concept that renal arterial and arteriolar disease is the cause of human essential hypertension, one must recall the limitations imposed by the study of a biopsy section from a living kidney. At best, more than 10 preglomerular arterioles can be identified, and since there are about 1,250,000 afferent glomerular arterioles in each kidney, a sample of 1 in 5,000 is obtained. Therefore, failure to see significant vascular changes in the small mass of kidney removed by biopsy can scarcely justify the conclusion that no such lesions exist. Besides, no biopsy of the cortex of the kidney can give any estimate of the condition of the renal artery or its main branches.

Dr. Smithwick has found less arteriolar disease in biopsy material obtained at operation than has been observed by others in autopsy material, and from this he concludes that "much of the arteriolar disease seen at death developed as a result of the hypertension." Since a renal biopsy affords an inadequate sample of the entire kidney, no correlation between biopsy and autopsy material can be made. Furthermore, the average age of his patients treated surgically was 37 years, whereas the average age of hypertensive patients who come to autopsy is much greater.

In assaying the ultimate therapeutic value of surgical operation on patients with vascular disease and hypertension, one must consider the relation of sex to the disease. In Dr. Smithwick's series there were 92 females and 64 males. Is it possible that the recognized vasomotor instability of the female has influenced Dr. Smithwick's favorable therapeutic results?

I agree that further observations are necessary to determine the duration of the beneficial effects of sympathectomy on hypertension. Whether or not the span of life is any longer for patients treated by surgical operation than it is for those treated medically has not been determined. No series of hypertensive patients subjected to operation has been more carefully and critically studied than that reported by Dr. Smithwick.

DR. REGINALD H. SMITHWICK, Boston: Dr. Scott has raised certain questions regarding the validity of biopsy material, and I think his point is correctly taken. I recognize the questionable value of biopsy material and have commented on it in various communications. When the biopsy specimen showed no evidence of renal vascular disease, of course it was wholly possible and perhaps even probable that serial sections of the kidney would have demonstrated vascular disease in other areas. On the other hand, when biopsy material showed severe arteriolar disease, such as grade 4, which is the most advanced grade and which is as advanced as is seen in autopsy material, then, as Dr. Scott has indicated, the data are probably significant, because it would be unlikely to obtain a renal biopsy specimen of grade 4 (severe arteriolar disease) and another of grade 0 (little or no disease) from another part of the kidney. There seems to be little difference in the effect of operation on blood pressure when the various grades of the renal biopsy specimens are taken into consideration. It is of interest that in the presence of a condition in which biopsy specimens look like autopsy material one can still obtain a striking result from operation; all of this leads one to wonder why the blood pressure is lower and how the lower level can be explained. It seems as though one would have to consider the probability of a decreased peripheral resistance to the flow of blood through some areas other than the kidneys. Such an explanation is further suggested by the favorable effect of operation on patients with primary renal disease, such as pyelonephritis.

# PROGRESS IN ORTHOPEDIC SURGERY FOR 1943

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE  
AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

(Continued from Page 146)

## IV. NEUROMUSCULAR DISORDERS EXCLUSIVE OF POLIOMYELITIS

PREPARED BY WINTHROP M. PHELPS, M.D., BALTIMORE

*Injuries to Nerves.*—In this series of disorders included injuries in or about the shoulder girdle due to a variety of causes. Hauser and Martin<sup>106</sup> present 2 additional cases of winged scapula occurring in the armed forces; in 1 case the condition resulted from repeated lifting of heavy objects and in the other from an automobile accident. In both there was isolated paralysis of the serratus anterior muscle.

Burnard and Fox<sup>107</sup> present 9 cases of multiple neuritis of the shoulder girdle resulting from various causes which occurred in the Second New Zealand Expeditionary Force.

Clausen<sup>108</sup> reviews the literature and reports cases of postoperative or anesthetic paralysis of the brachial plexus.

Ramirez<sup>109</sup> reports several cases of brachial paralysis following the administration of serum.

Saksena<sup>110</sup> reports paralysis of the serratus anterior muscle following glandular fever.

ED. NOTE.—This series of papers is especially interesting because of the varied causes of similar resultant conditions. The brachial plexus is apparently susceptible to injury, and may be in part explained by the high degree of mobility of the entire structure of the shoulder girdle and the consequently greater exposure to stretching and other trauma.]

6. Hauser, C. U., and Martin, W. F.: Two Additional Cases of Traumatic Winged Scapula Occurring in the Armed Forces, *J. A. M. A.* **121**:667-668 (Feb. 27) 1943.

7. Burnard, E. D., and Fox, T. G.: Multiple Neuritis of Shoulder Girdle: A Report of Nine Cases Occurring in the 2nd New Zealand Expeditionary Force, *Zealand M. J.* **41**:243-247 (Dec.) 1942.

8. Clausen, E. G.: Postoperative ("Anesthetic") Paralysis of Brachial Plexus: Review of Literature and Report of Nine Cases, *Surgery* **12**:933-942 (Dec.) 1942.

9. Ramirez, F.: Parálisis post-séricas, *Arch. urug. med. cir. y especialid.* **21**:545-550 (Nov.) 1942.

10. Saksena, H. C.: Paralysis of Serratus Anterior Following Glandular Fever, *Brit. M. J.* **2**:267 (Aug.) 1943.

*Disease Entities.*—Milhorat<sup>111</sup> describes cases of familial progressive muscular atrophy of the peroneal type associated with atrophy of the optic nerve. The peroneal type of muscular atrophy is well known but is not by any means always a familial disease. When it is associated with atrophy of the optic nerve it probably is a different entity, with a different cause, as this interesting presentation suggests.

Swank and Putnam<sup>112</sup> present a clinical analysis of amyotrophic lateral sclerosis and related conditions of muscular atrophy and discuss the differential diagnosis between amyotrophic lateral sclerosis and primary lateral sclerosis and progressive muscular atrophy. The paper deals with the finer points of distinction, as they have a bearing on the treatment and the course of the conditions.

Swank and Price<sup>113</sup> discuss the origin of fascicular muscular twitchings in amyotrophic lateral sclerosis.

Milhorat and Wolff<sup>114</sup> have analyzed on a statistical basis the relationship between the time of onset of symptoms and the clinical course of progressive muscular dystrophy.

Lubin, Marburg and Tamaki<sup>115</sup> bring out the relationship of familial muscular atrophy to other

111. Milhorat, A. T.: Studies in Diseases of Muscle: Progressive Muscular Atrophy of Peroneal Type Associated with Atrophy of Optic Nerve; Report on a Family, *Arch. Neurol. & Psychiat.* **50**:279-287 (Sept.) 1943.

112. Swank, R. L., and Putnam, T. J.: Amyotrophic Lateral Sclerosis and Related Conditions: Clinical Analysis, *Arch. Neurol. & Psychiat.* **49**:151-177 (Feb.) 1943.

113. Swank, R. L., and Price, J. C.: Fasciculation-Muscle Twitchings in Amyotrophic Lateral Sclerosis: Their Origin, *Arch. Neurol. & Psychiat.* **49**:221-227 (Jan.) 1943.

114. Milhorat, A. T., and Wolff, H. G.: Studies in Diseases of Muscle: Heredity of Progressive Muscular Dystrophy; Relationship Between Age at Onset of Symptoms and Clinical Course, *Arch. Neurol. & Psychiat.* **49**:641-654 (May) 1943.

115. Lubin, A. J.; Marburg, O., and Tamaki, K.: Familial Type of Paralysis in Infants and Its Relationship to Other Heredofamilial Disorders: Clinical and Pathologic Study, *Arch. Neurol. & Psychiat.* **49**:274-284 (Jan.) 1943.

redofamilial neurologic disorders in a clinico-pathologic study.

Homburger<sup>116</sup> points out the changes in the thymus, particularly those associated with myasthenia gravis which he observed in 6,000 topsies.

Mueller and Sugar<sup>117</sup> have found instances of familial syringomyelia.

[ED. NOTE.—All of the preceding papers are interesting from the point of view of analyses of the diseases, clinically and pathologically, and from the point of view of differential diagnosis, but it is also interesting that in the literature for 1943 there are relatively few articles concerning advancement of therapy. What has been accomplished seems still to be related to the use of neostigmine compounds, atropine derivatives and vitamins. The reports on treatment are discussed later in this section.]

DeJong<sup>118</sup> reports a case of the syndrome of involvement of the posterior cord of the brachial plexus, resulting from a traumatic anterior dislocation of the shoulder, with loss of function in the deltoid and the teres major muscle and the other muscles which are supplied by the axillary nerve and the related nerves comprising the posterior cord of the brachial plexus.

Sahs and Paul<sup>119</sup> describe the differential diagnosis between neuronitis and poliomyelitis and point out the chief distinguishing characteristics of the two diseases. They also show that the use of the "Kenny" treatment did not forestall an increase in the paralysis in the progressive phase of the disease (neuronitis).

Hassin<sup>120</sup> discusses Landry's paralysis and points out that it is not an entity but a symptom complex. He emphasizes that in every case the muscles of respiration and the condition of the heart should be examined carefully, in addition to the usual areas of involvement, because of the relationship of these muscles to the course of the disease.

16. Homburger, F.: Changes in Thymus with Special Reference to Myasthenia Gravis: Observations in Autopsies of Six Thousand Autopsies, *Arch. Path.* 36:371-374 (Oct.) 1943.

17. Mueller, C. R., and Sugar, S. J.: Familial Syringomyelia, *J. A. M. A.* 122:743-744 (July 10) 1943.

18. DeJong, R. N.: Syndrome of Involvement of Posterior Cord of Brachial Plexus, *Arch. Neurol. & Psychiat.* 49:860-862 (June) 1943.

19. Sahs, A. L., and Paul, W. D.: Neuronitis: Differentiation from Poliomyelitis, *Arch. Phys. Therapy* 39:395-401 (July) 1943.

20. Hassin, G. B.: Landry's Paralysis: Its Clinical and Pathologic Features, *J. Neuropath. & Exper. Neurol.* 2:293-300 (July) 1943.

*Cerebral Palsy.*—Dynes<sup>121</sup> discusses the prevalence of subacromial bursitis in conjunction with neurologic conditions such as hemiplegia. Bursitis associated with a neurologic condition is not treated any differently than when it occurs independently, but the treatment must be modified by the course of the associated disease.

Norfleet and Arena<sup>122</sup> emphasize the responsibility of the pediatrician to infants with cerebral palsy and the importance of classification of the condition, which can be made as a result of early tests and examinations of infants with suspected birth injury.

Shapiro<sup>123</sup> surveys the literature on aseptic lymphocytic meningitis and discusses the cause, the clinical picture and the pathologic changes. He then presents a case in which this condition is associated with infantile cerebral palsy in the adult form. The differential diagnosis is considered.

Barr<sup>124</sup> describes a procedure for transplantation of a muscle for combined flexion-internal rotation deformity of the thigh in spastic paralysis. This operation is limited to true spastic cerebral birth palsy and does not succeed in athetosis. It consists in freeing the tensor fasciae latae, with the anterior third of the gluteus medius and minimus muscles, from their iliac origins and reattaching them to the ilium at a point slightly posterior to the greater trochanter. Results were satisfactory.

McCarroll and Schwartzmann<sup>125</sup> analyze 1,720 cases of spastic paralysis and allied disorders from the standpoint of classification, characteristics and etiology. In 1,217 cases the pyramidal tract was involved, and these cases were discussed with regard to extremities involved, requirements for surgical correction and reasons for avoiding surgical intervention.

They list the deformities for which surgical intervention is justified in cases of involvement of the pyramidal tract (or spastic) paralysis. They point out also that the presence of athetosis

121. Dynes, J. B.: Subacromial Bursitis Associated with Diseases of Nervous System, *Lahey Clin. Bull.* 3:124-127 (April) 1943.

122. Norfleet, G. M., and Arena, J. M.: Cerebral Palsy and the Pediatrician, *North Carolina M. J.* 4:55-58 (Feb.) 1943.

123. Shapiro, L. B.: Aseptic Lymphocytic Meningitis in a Case of Infantile Cerebral Palsy, *Adult Form*, *J. Nerv. & Ment. Dis.* 97:166-169 (Feb.) 1943.

124. Barr, J. S.: Muscle Transplantation for Combined Flexion-Internal Rotation Deformity of Thigh in Spastic Paralysis, *Arch. Surg.* 46:605-607 (May) 1943.

125. McCarroll, H. R., and Schwartzmann, J. R.: Spastic Paralysis and Allied Disorders, *J. Bone & Joint Surg.* 25:745-767 (Oct.) 1943.



is usually a contraindication to surgical procedures on the extremities.

Deaver and Brown<sup>126</sup> describe the vocational rehabilitation of persons handicapped by cerebral palsy and the results obtained in working with adults with this condition.

St. James<sup>127</sup> describes a new type of skis for training persons with cerebral palsy to walk, which permits a normal reciprocal arm swing in the gait.

Lundeen,<sup>128</sup> Werner<sup>129</sup> and Leone Bloise,<sup>130</sup> in three separate papers, present and discuss different aspects of the general problem of the care and treatment of persons with cerebral palsy.

*Surgical Procedure for Neuromotor Conditions.*—Stabins and Mathews<sup>131</sup> report neurolysis and transposition of the nerve as the operation of choice in the treatment of traumatic paralysis of the ulnar nerve. Their results with this operation have been superior to those with other methods.

Thomsen, Altamirano and Luco<sup>132</sup> have studied the effects of tenotomy on neuromuscular transmission and present some interesting data, which may have a bearing on other variations in transmission, which have been studied in the laboratory.

Dandy<sup>133</sup> describes a method of restoring the function of nerves which require resection for removal of neuromas. He states that to avoid complications nerves should be resutured end to end at the earliest possible moment compatible with the patient's condition and the condition of the wound. If the patient is not seen until

later, however, he advises resection and shaping of the bone by osteotomy, to prevent strain on the nerve; the bone should be sufficiently shortened to allow accurate suturing. A neuroma has to be excised the shortening of bone should be sufficient to allow suturing without undue tension on the suture line.

The paper of Highet and Sanders<sup>134</sup> and of Highet and Holmes<sup>135</sup> are of interest in same connection. The first describes the effect of stretching nerves in general after suture and the second, the results of traction injuries to peripheral nerves in particular.

*Physical Therapy for Neuromuscular Disorders.*—DeJong<sup>136</sup> describes a new instrument which is a portable electrostimulator, to be used on nerves and muscles, both for diagnostic and for therapeutic purposes. As a diagnostic it is valuable, because of its compactness and portability, for determining conditions of peripheral nerve (injury, inflammation, etc.) and for determining the reaction of degeneration. It is also of value in determining decreased excitability to galvanic current (as in myasthenia). For therapeutic purposes it can be used to stimulate paralyzed muscles in peripheral lesions to prevent atrophy, to supply galvanic current and to introduce substances into tissues (iontophoresis).

Solandt, DeLury and Hunter<sup>137</sup> present the effects of electrical stimulation on atrophy of denervated skeletal muscle. They conclude that electrical stimulation is effective in reducing the loss of weight of denervated muscle; this conclusion bears out those of other workers in this respect.

They found that a 25 cycle sinusoidal current is better than a 60 cycle current but that both are superior to galvanic and faradic currents.

The effectiveness of treatment increases with the number of treatments, but the length of each treatment is much less important.

134. Highet, W. B., and Sanders, F. K.: Effects of Stretching Nerves After Suture, *Brit. J. Surg.* **31**: 355-369 (April) 1943.

135. Highet, W. B., and Holmes, W.: Traction Injuries to Lateral Popliteal Nerve and Traction Injuries to Peripheral Nerves After Suture, *Brit. J. Surg.* **31**: 212-233 (Jan.) 1943.

136. DeJong, H.: New Single-Unit Portable Electrostimulator of Nerves and Muscles, *J. Nerv. & Ment. Dis.* **97**: 563-566 (May) 1943.

137. Solandt, D. Y.; DeLury, D. B., and Hunter, I.: Effect of Electrical Stimulation on Atrophy of Denervated Skeletal Muscle, *Arch. Neurol. & Psychol.* **60**: 802-807 (June) 1943.

126. Deaver, G. G., and Brown, M. E.: Making Man Power: Vocational Rehabilitation of Those Handicapped by Cerebral Palsy, *Arch. Phys. Therapy* **23**: 719-728 (Dec.) 1942.

127. St. James, R.: Reciprocal Action Skis in Treatment of Cerebral Palsy, *Physiotherapy Rev.* **23**: 199-200 (Sept.-Oct.) 1943.

128. Lundeen, P.: Cerebral Palsy or Spastic Paralysis, *Physiotherapy Rev.* **23**: 17-21 (Jan.-Feb.) 1943.

129. Werner, A.: Spastic Paralysis: Problem of Little's Disease, *Psychiat.-neurol. Wchnschr.* **44**: 402 (Dec. 19) 1942.

130. Leone Bloise, N.: Reeducación psico-motriz en niños lisiados y espasmódicos, *Arch. de pediat. d. Uruguay* **14**: 201-208 (April) 1943.

131. Stabins, S. J., and Mathews, W. H.: Traumatic Ulnar Nerve Palsy: Neurolysis and Transposition of Nerve; the Operation of Choice, *U. S. Nav. M. Bull.* **41**: 1381-1388 (Sept.) 1943.

132. Thomsen, P.; Altamirano, M., and Luco, J. V.: Efectos de la tenotomía sobre la transmisión neuromuscular, *Medicina, Buenos Aires* **3**: 67-75 (Oct.) 1942.

133. Dandy, W. E.: Method of Restoring Nerves Requiring Resection, *I. A. M. A.* **122**: 35-36 (May 1)

Three papers are recorded dealing with various phases of the treatment of muscles after injury to a nerve. The first, by Hines,<sup>138</sup> discusses the physiologic basis for treatment; the second, by Chamberlain,<sup>139</sup> points out the relation of physical therapy to injuries of the peripheral nerves, and the third, by Dube,<sup>140</sup> discusses physical therapy following suturing of nerves.

Staples and Watkins<sup>141</sup> describe 2 cases in which full active abduction was possible after paralysis of the deltoid muscle. They state that this is possible by the interaction of the supraspinatus, infraspinatus, pectoralis major, coracobrachialis, long head of the biceps, serratus magnus and trapezius muscles. Different groups of these muscles operate to bring about abduction in different positions of internal and external rotation. They advocate careful training and study of cases of isolated paralysis of the deltoid muscle before resorting to surgical operation.

*Drug Therapy for Neuromuscular Disorders.*—All the reports on therapy deal with three general classes of drugs: vitamin E (alpha tocopherol), atropine (and its derivatives) and neostigmine.

In regard to vitamin E, Houchin and Mattill,<sup>142</sup> in experiments on animals, compare the oxygen consumption, the creatine content and the chloride content of muscles of animals deficient in vitamin E with those of normal animals and report the effect of feeding tocopherol to the deficient animals.

The same authors, in another paper,<sup>143</sup> describe the changes in metabolic processes produced by injection of alpha tocopherol phosphate into dystrophic muscles.

Houchin,<sup>144</sup> in a third paper, shows the in vitro effect of alpha tocopherol phosphate on oxidation in muscle tissue.

138. Hines, H. M.: Physiologic Basis for Treatment of Paralyzed Muscle, *Arch. Phys. Therapy* **24**: 9-73 (Feb.) 1943.

139. Chamberlain, R. D.: Some Aspects of Physical Therapy in Relation to Peripheral Nerve Injuries, *Arch. Phys. Therapy* **24**:603-609 (Oct.) 1943.

140. Dube, P.: Symposium on Military Physical Medicine: Physical Therapy Following Suture of Nerves, *M. Clin. North America* **27**:1091-1096 (July) 1943.

141. Staples, O. S., and Watkins, A. L.: Full Active Abduction in Traumatic Paralysis of Deltoid, *J. Bone & Joint Surg.* **25**:85-89 (Jan.) 1943.

142. Houchin, O. B., and Mattill, H. A.: Oxygen Consumption, Creatine, and Chloride Content of Muscles from Vitamin E-Deficient Animals as Influenced by Feeding  $\alpha$ -Tocopherol, *J. Biol. Chem.* **146**:301-307 (Dec.) 1942.

143. Houchin, O. B., and Mattill, H. A.: Influence of Parenteral Administration of  $\alpha$ -Tocopherol Phosphate on Metabolic Processes in Dystrophic Muscle, *J. Biol. Chem.* **146**:309-312 (Dec.) 1942.

Hines, Lazere, Thomson and Cretzmeyer<sup>145</sup> discuss the role of vitamin E in neuromuscular atrophy and regeneration.

Septien<sup>146</sup> records results of the use of vitamin E on muscular atrophy following poliomyelitis.

[Ed. NOTE.—The preceding papers suggest that vitamin E plays some part in the metabolism of muscle and that it is of value when there is a vitamin E deficiency in the diet or in conditions in which vitamin E is destroyed by a disease process with resultant E avitaminosis. Work has been carried on in the last few years on all phases of the problem in many laboratories. In the reports of 1942, many of which were clinical, the results of using vitamin E therapeutically were discouraging, but many of the workers are continuing the investigation because of the overwhelming evidence concerning its therapeutic value found in laboratory studies. Advances in the understanding of the effect of lack of vitamin E are still being made; the problem will probably become more and more clarified.]

Soskin and Levine<sup>147</sup> demonstrate that muscular atrophy following section of nerves in monkeys can be inhibited by the use of atropine sulfate; they had previously shown that atropine decreased the degree of atrophy in rats also. They feel that because of this demonstration in monkeys it might be of therapeutic value for human beings.

Fischer<sup>148</sup> also shows the influence of atropine on muscular contractions in denervated skeletal muscles of rats.

Lazere, Thomson and Hines<sup>149</sup> and Solandt, DeLury and Hunter<sup>150</sup> contribute to the sub-

144. Houchin, O. B.: In Vitro Effect of  $\alpha$ -Tocopherol and Its Phosphate Derivative on Oxidation in Muscle Tissue, *J. Biol. Chem.* **146**:313-321 (Dec.) 1942.

145. Hines, H. M.; Lazere, B.; Thomson, J. D., and Cretzmeyer, C. H.: Role of Vitamin E in Neuromuscular Atrophy and Regeneration, *Am. J. Physiol.* **139**: 183-187 (June) 1943.

146. Septien, R.: Vitamin E in Treatment of Muscular Atrophies Following Infantile Paralysis, *J. Am. Inst. Homeop.* **36**:17-18 (Jan.) 1943.

147. Soskin, S., and Levine, R.: Influence of Atropine on Atrophy of Denervated Skeletal Muscle of Monkey (Macacus Rhesus), *Am. J. Physiol.* **138**:251-253 (Jan.) 1943.

148. Fischer, E.: Influence of Atropine on Atrophy of Denervated Skeletal Muscle of the Rat, *Proc. Soc. Exper. Biol. & Med.* **51**:208-209 (Nov.) 1942.

149. Lazere, B.; Thomson, J. D., and Hines, H. M.: Effect of Atropine upon Atrophy and Neuromuscular Regeneration, *Proc. Soc. Exper. Biol. & Med.* **53**:83-84 (May) 1943.

150. Solandt, D. Y.; DeLury, D. B., and Hunter, J.: Effect of Atropine and Quinidine Sulphate on Atrophy and Fibrillation in Denervated Skeletal Muscle, *Am. J. Physiol.* **140**:247-255 (Nov.) 1943.

ject on the effects of atropine sulfate on atrophy of muscles, and the latter group of writers also discuss the effect of quinidine sulfate on atrophy of muscle.

Altschul<sup>151</sup> investigated the question of whether muscular atrophy due to denervation and degeneration could be delayed or avoided by treatment with neostigmine and acetylcholine.

From the standpoint of loss of weight the treatment apparently had no effect, but histologic studies showed definitely that the atrophy was slighter and degenerative phenomena were lacking. These results were true for cats but not for rabbits. He feels that since different species of animals differ in their response there should be differences in the response of persons and also in the response of different muscle groups throughout the body.

Odom, Russel and McEachern<sup>152</sup> discuss the effects of neostigmine on myasthenia gravis and progressive muscular atrophy.

151. Altschul, R.: Effect of Prostigmine and Acetylcholine on Denervated Muscle, with Remarks on Some General Effects of These Drugs, *J. Nerv. & Ment. Dis.* 97:549-562 (May) 1943.

Their conclusions are that the abnormal myograms of patients with myasthenia gravis become normal within forty-five minutes after intramuscular injection of neostigmine methyl sulfate. In 3 cases of progressive muscular atrophy a small dose of neostigmine intensifies fasciculation. Fasciculation does not occur in normal persons with so small a dose.

Thus the drug possesses a definite value as diagnostic aid in both of these diseases.

Eaton<sup>153</sup> emphasizes that neostigmine methyl sulfate is of value in a diagnostic test for myasthenia gravis because of its strengthening effect and that diagnosis can still further be confirmed by the use of quinine, which has a characteristic weakening effect.

152. Odom, G.; Russel, C. K., and McEachern, D.: Studies of Neuromuscular Disorders: Myogram, Blood Cholinesterase and Effect of Prostigmine in Myasthenia Gravis and Progressive Muscular Atrophy, *Brain* 66: 1-17 (March) 1943.

153. Eaton, L. M.: Diagnostic Tests for Myasthenia Gravis with Prostigmine and Quinine, *Proc. Staff Meet. Mayo Clin.* 18:230-236 (July 14) 1943.

#### V. TUMORS OF BONE AND OF SYNOVIAL MEMBRANE

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*Classification of Tumors of Bone.*—Caldwell<sup>154</sup> presents a classification that is employed at the Baylor Tumor Clinic:

- A. Benign tumors of bone
  1. Osteochondromas
  2. Multiple exostoses
  3. Chondromas and chondromyxomas
  4. Osteomas
  5. Benign giant cell tumors
  6. Hemangiomas
- B. Malignant tumors of bone
  1. Osteogenic sarcomas
    - (a) Chondromyxosarcomas
      - (1) Primary chondromyxosarcomas
      - (2) Chondrosarcomas (secondary)
    - (b) Periosteal osteoblastic sarcomas
      - (1) Sclerosing type
      - (2) Osteoid type
      - (3) Fibrous type
    - (c) Fibrosarcomas of bone
    - (d) Chondroblastic sarcomas (osteolytic)
    - (e) Endosteal osteoblastic sarcomas (osteolytic)
    - (f) Malignant giant cell tumors
  2. Ewing sarcomas

3. Multiple myelomas (Bence-Jones proteinuria present in 50 per cent of cases)
4. Chloromas, chloroleukosarcomas and chloromyelosarcomas
5. Reticuloendothelial sarcomas
6. Chordomas

- C. Metastatic tumors of bone and bone marrow
  1. Secondary carcinomas
  2. Lymphosarcomas
  3. Melanosarcomas
  4. Neuroblastomas and retinoblastomas

Budd and MacDonald<sup>155</sup> note confusion relative to the classification of tumors of bone. They present a modified classification as adopted by the Registry of Bone Sarcoma in 1939.

Meyerding<sup>156</sup> discusses briefly certain confusing terms employed and presents his classification of tumors of bone as follows:

155. Budd, J. W., and MacDonald, I.: A Modified Classification of Bone Tumors, *Radiology* 40:555-560 (June) 1943.

156. Meyerding, H. W.: Classification of Bone Tumors, *Proc. Staff Meet., Mayo Clin.* 18:17-18 (June 27) 1943.

154. Caldwell, G. T.: Classification of Bone Tumors, *Texas State J. Med.* 39:282-285 (Sept.) 1943.

NEOPLASMS OF BONE AND LESIONS SIMULATING THEM

I. Lesions simulating neoplasms of bone

A. Inflammatory lesions

1. Traumatic lesions (callus; ossifying hematoma)
2. Infections (syphilis; tuberculosis; osteomyelitis; nonsuppurative osteomyelitis of Garré; Brodie's abscess; myositis ossificans; osteoperiostitis)

B. Osteitis fibrosa cystica

C. Metabolic lesions

1. Hand-Schüller-Christian disease; Gaucher's disease; Niemann-Pick disease; hyperparathyroidism

D. Nutritional lesions

1. Rickets; scurvy

I. Neoplasms of bone

A. Benign osteogenic tumors

1. Osteoma (exostosis)
2. Chondroma

B. Fibroblastic tumors

1. Benign fibroma
2. Malignant periosteal and cortical

C. Giant cell tumors

1. Benign giant cell tumor
2. Malignant giant cell sarcoma

D. Vascular neoplasms

1. Benign hemangioma (cavernous or plexiform); lymphangioma
2. Malignant hemangio-endothelioma (diffuse endothelioma or Ewing's tumor); lymphangio-endothelioma

E. Malignant osteogenic sarcoma (including chondrosarcoma)

F. Multiple myeloma

G. Metastatic tumors

H. Miscellaneous group

1. Undifferentiated malignant neoplasms
2. Lymphosarcoma; liposarcoma; erythroblastoma; chloroma; adamantinoma

*Lesions Simulating Neoplasms of Bone.*—Kernwein and Queen<sup>157</sup> state that solitary eosinophilic granuloma is an uncommon benign destructive lesion of bone, of which there are 19 cases reported in the literature. It has been seen among young or adolescent male patients, with a presenting symptom of swelling or pain or both. The lesion is solitary, and in 12 of the 19 cases it was located in the skull or the ribs. The treatment was surgical, alone or combined with roentgen therapy. They present data on 1 case. Rogers<sup>158</sup> presents data on 2 cases of cyst in the upper part of the humerus. Treatment consisted of excavating the cystic cavity and packing it with chips of bone, after which two full cortical thickness grafts from the tibia were

inserted as struts. The proximal portions of the grafts were placed through the cystic region to extend to the head of the humerus, and the lower ends were fixed by screws to the shaft. No external fixation was used. Satisfactory healing and good functional results occurred in both cases.

Barden<sup>159</sup> presents data on a case of cystic tumor of the proximal phalanx of the little finger of a patient, which had been present for thirty years. There had been slow and progressive swelling. No biopsy was performed, but the roentgenologic picture was suggestive of solitary cyst of the bone or benign giant cell tumor. He draws attention to the paucity of American and English literature concerning irradiation treatment of cysts of bone.

Bennett<sup>160</sup> presents an unusual series of roentgenograms showing the development of a bone cyst of the solitary type. They had been taken nine months apart, between May 1938 and November 1941, as an index of the normal development of a child. The development of the cyst was incidental to the desired records. The first roentgenogram was normal. The following one showed a small defect in the upper part of the tibia, which appeared larger in subsequent roentgenograms. The cyst was removed surgically, and the pathologic report was typical giant cell tumor of bone (benign). There were never any subjective symptoms.

Brugsch<sup>161</sup> presents data on a case of Hand-Schüller-Christian disease. The lesion was discovered during a routine roentgenographic examination of the lungs of an 18 year old Jewish youth. He discusses the differential diagnosis of pseudocystic diseases of bone, which include: (1) hyperparathyroidism; (2) fibrous dysplasia of bone (Lichtenstein; Albright); (3) dyschondroplasia; (4) osteitis deformans; (5) multiple myeloma and metastatic malignant growth; (6) lipidosis: Gaucher's disease, osseous xanthomatosis and Schüller-Christian disease.

Furst and Shapiro<sup>162</sup> discuss the several hypotheses of the causation of fibrocystic disease of bone of the polyostotic type. Although each hypothesis explains in part some manifestation, none gives ultimate and direct proof as to the exact cause. (The relationship of dermal pig-

159. Barden, S. P.: Bone Cyst Successfully Treated with X-Rays, *Radiology* 39:732-733 (Dec.) 1942.

160. Bennett, C. B.: Notes on an Early Bone Cyst, *Arch. Surg.* 46:608-610 (May) 1943.

161. Brugsch, H. G.: Pseudocystic Bone Disease (Lipidosis of the Bones), *Bull. New England M. Center* 4:284-290 (Dec.) 1942.

162. Furst, N. J., and Shapiro, R.: Polyostotic Fibrous Dysplasia: Review of the Literature with Two Additional Cases, *Radiology* 40:501-515 (May) 1943.

157. Kernwein, G. A., and Queen, F. B.: Solitary Eosinophilic Granuloma, *Surgery* 14:105-110 (July) 1943.

158. Rogers, W. A.: An Operation for Benign Cyst of the Upper Humeral Metaphysis, *Arch. Surg.* 46:9-761 (May) 1943.

mentation, pathologic changes of bone and sometimes sexual precocity is an unusual one and perhaps cannot be completely evaluated in a single theoretic statement.) They mention the fact that the results of all laboratory examinations may be within normal limits. The condition must be distinguished from hyperparathyroidism, regional fibrocystic disease, dyschondroplasia (Ollier), rarely Paget's disease, leontiasis ossea and Hand-Schüller-Christian disease. They present data on 2 cases, in 1 of which the patient was a boy of 15 years, without endocrine disorders or pigmentation. Roentgenographic examination of the bones was done because of facial asymmetry and old injury to the arm. The initial diagnosis was osteitis fibrosa cystica. In the other case the patient was a 17 year old girl. There was a history of menses at 3 years of age and full maturation of secondary sexual characteristics at 9 years. The patient was examined because of swelling of the elbow after injury. Previous exploration of the parathyroid glands had revealed no abnormality. The results of all laboratory studies were within normal limits except for some variation in the results of the phosphatase tests in the first case.

*Lesions of Tendon Sheath.*—Shepherd<sup>163</sup> presents data on a case of osteochondroma arising from the sheath of the flexor tendon of the index finger. He states that tumors of the sheaths are uncommon, the most frequent being giant cell tumor and xanthoma. A review of data on the cases in the literature reveals that osteochondromas are observed usually near the bony insertion of the tendon, whereas in this case the tumor was located near the base of the index finger. Microscopic examination showed that the tumor consisted of hyaline cartilage with some calcification in the central portion.

Cristol and Gill<sup>164</sup> present data on a case in which the patient had extensive xanthoma of the tendon sheath of the left foot. Operation was performed at the University of Pennsylvania Hospital. The condition presented difficulties in diagnosis and treatment; a pathologic diagnosis of "mixed cell sarcoma" and of "xanthomatous tissue" had been made on two occasions, and roentgen therapy had failed to control the growth of the lesion, so that finally amputation of the left leg was performed. Alteration in lipid metabolism was the primary etiologic factor, trauma or infection or both being secondary factors.

163. Shepherd, J. A.: Osteochondromata of Tendon-Sheaths: A Case Arising from the Flexor Sheath of the Index Finger, *Brit. J. Surg.* 30:179-180 (Oct.) 1942.

164. Cristol, D. S., and Gill, A. B.: Xanthoma of Tendon Sheath, *J. A. M. A.* 122:1013-1014 (Aug. 7) 1943.

*Benign Neoplasms of Bone.*—Enchondroma: Jaffe and Lichtenstein,<sup>165</sup> in their customary precise manner, present data on 28 cases of solitary benign enchondroma of bone. They emphasize the fact that the tumor occurs most often in bones of the limbs and especially in the phalanx of the fingers, the metacarpal bones, the humerus and the femur. The tumor usually has its niche in the metaphysal portion of the bone. It may extend to the epiphysis after fusion. It usually thins and distends the cortex, producing definite bulge. Symptoms are minimal, usually only the bulging of a finger laterally with slight tenderness or ache. Roentgenographic study reveals the typical region of rarefaction, usually without evidence of calcification, but small deposits of calcified deposits may be present in tumors of the large bones. The ultimate diagnosis of benign enchondroma rests on the microscopic finding of, usually, mononuclear cartilage cells, the nucleus being small in relation to the cell and any binuclear cells, especially, showing small nuclei. Enchondroma of long tubular bones may undergo malignant changes, of which the early manifestations are microscopic only and consist of cells with plump nuclei or large cartilage cells with especially large nuclei.

Chondroma: Olsman and Lev<sup>166</sup> present data on a case of chondroma of the sacrococcygeal region. The patient was an Italian man, 73 years of age, who had psychosis with cerebral arteriosclerosis. He had had an injury to the base of his spinal column eleven years prior to admission to the hospital and had had two operations. Roentgenographic examination revealed cystic degeneration of the sacrum with calcified regions. In 1940 laparotomy disclosed that the peritoneal cavity contained fecal-smelling fluid. The patient died the day following the operation. Necropsy showed involvement of the peritoneum with peritonitis. Otherwise the usual symptoms and signs of a slow growing sacrococcygeal chondroma with anterior and posterior extension were present: (1) pain; (2) palpable mass observed on rectal examination; (3) roentgenologic findings of destruction of the sacrum, and (4) constipation.

Lehmann<sup>167</sup> reports data on a case of "myxofibroma" of the right tibia in which there

165. Jaffe, H. L., and Lichtenstein, L.: Solitary Benign Enchondroma of Bone, *Arch. Surg.* 46:499-503 (April) 1943.

166. Olsman, L., and Lev, M.: Sacrococcygeal Chondroma: Report of a Case, *Am. J. Surg.* 60:115-117 (April) 1943.

167. Lehmann, O.: "Myxofibroma" of Bone: Report of a Case Involving a Tibia, *Bull. Hosp. Joint Dis.* 4:12-15 (April) 1943.

as involvement of the upper part of the diaphysis. Operation was done on Nov. 4, 1942. The condition had apparently followed an injury twelve years previously. The operation consisted of excision and swabbing of the wound with 50 per cent solution of zinc chloride. The patient had obtained an excellent result at the time of Lehmann's report. The author states that 3 other such cases had been observed in the Hospital for Joint Diseases, in all of which the lesions had had identical histologic features. There had been no recurrence of the lesion in any of the cases.

**Giant Cell Tumor.**—Lopez<sup>168</sup> discusses giant cell tumors of the long bones. He states that these tumors are frequently found in patients between 16 and 54 years of age and are located in the epiphysis of the long bones. There is a history of trauma or of an inflammatory process. The tumor consists of giant cells, fibrous tissue and vessels. Pain and the presence of the tumor are the principal findings on examination; no fever or loss of weight is noticed. The condition should be distinguished from cyst, fibrous osteitis (von Recklinghausen's disease) and malignant tumor of bone. Malignant tumors are subdivided into the following: osteogenic sarcoma, Ewing's tumor and myeloma. Treatment should be conservative, and in the event that it fails amputation is indicated.

Levine<sup>169</sup> reports data on the sixteenth case of giant cell tumor of the patella in the literature. The patient was a white man 31 years of age, who complained of pain over the medial aspect of the right knee and tenderness of the knee up which had followed an injury one year previously. Examination revealed atrophy of the thigh and calf with slight swelling of the knee. Roentgenographic study revealed irregular cystic regions occupying two thirds of the patella. The patella was excised and a cast applied. The postoperative course was uneventful. Trauma as apparently the cause in this case.

Gershon-Cohen<sup>170</sup> reviews data on 29 cases of giant cell tumor in which the late results of roentgen therapy were good, yielding cures in possibly more than 85 per cent of the cases (follow-up reports varied from five to thirteen years after treatment). Less morbidity and better recalcification of the tumor occur than after surgical treatment, and the complications of re-

currence and infection may be prevented. Weight bearing should be avoided during treatment, and afterward until healing has progressed fairly well. Therapy need not be given in large doses or for a long time.

Gendreau and Pinsonneault<sup>171</sup> report on pathologic forms of osteoclasia (osteoclastoma, giant cell tumor and epulis) and clinical manifestations of osteitis fibrosa. They explain the pathogenesis and the clinical manifestations of the so-called processes of osteofibrosis on the basis of the physiologic activity of the osseous tissue. This is said to be in a constant state of renewal by means of a process of destruction and reconstruction, that ends in a gradual mechanical perfection of the skeleton. Destruction takes place slowly and completely by osteoclasia or quickly and partially by osteolysis. Regeneration is prompt and direct by fibrous ossification. Any imbalance between the two main processes leads to a pathologic condition known as osteofibrosis. This, they consider, occurs in three stages: 1. Destruction (patchy or diffuse) by osteolysis, with the main structure of the bone left intact, or by osteoclasia, with nothing left of the dead tissue but a hemorrhagic focus that can take the shape of a cystic cavity. Calcium is liberated in both instances, and the liberated calcium may remain localized or may produce hypercalcemia. 2. Fibrous proliferation. This may take its origin from the connective tissue left by osteolysis, or it may be a new formation originating in the hemorrhagic focus left by osteoclasia (polymorphic roentgenologic aspects of Paget's disease and encapsulated and areolar aspect of giant cell tumor). 3. Calcification of the preosseous substance. This may occur early or late.

The authors emphasize the fact that a focus of osteitis fibrosa may show simultaneously all three stages in its different parts. In Paget's disease destruction is marked at the onset and calcification at the end. There is not much liberation of calcium, but the blood phosphate level may be elevated as a result of the increased constructive activity. In von Recklinghausen's disease destruction is more extensive than in Paget's disease, and consequently functional changes and deformities are greater. Calcification decreases with progress of the disease, and the calcium level is always high in the blood, while the phosphate level shows little change. They present a table of all known forms of osteofibrosis. The clinical

171. Gendreau, J. E., and Pinsonneault, G.: *Considérations sur les formes pathologiques de l'ostéoclasie et les manifestations cliniques de l'ostéite fibreuse, avec quinze observations personnelles*, Union méd. du Canada 72:1032-1056 (Sept.) 1943.

168. Lopez, C. P.: *Tumores oseos a células gigantes de los huesos largos*, Día méd. 15:388-395 (April 26) 1943.

169. Levine, M. A.: *Giant Cell Tumor of the Patella: Case Report*, Am. J. Surg. 62:286-289 (Nov.) 1943.

170. Gershon-Cohen, J.: *Giant-Cell Tumors: Radiation Therapy and Late Results*, Radiology 41:261-267 (Sept.) 1943.

manifestations of osteofibrosis vary with the nature of the bone tissue in which they take place: Its manifestations in the bones of a child are different from those in the bones of an adult; its character in the long bones is not the same as it is in the short ones. Osteoclastic lesions, such as giant cell tumors, do not occur in bones of membranous origin, such as the frontal and the parietal bone. Those described as present in the upper maxillary region actually come from the ethmoid bone, which originates from cartilage. Osteoclastomas are most frequent and malignant in bones in which spongy tissue is abundant, and their malignancy decreases when they occur in the long bones far from the epiphysis. They are also more benign in the proximity of fibrous tissue and extremely benign in the flat bones. In some cases the origin of giant cell tumor may be related to a softening of the periosteum and compact bone, and their malignancy increases with age, because of a limited activity of the periosteum in old people. The authors illustrate their paper with data on 15 personal cases, 2 of which were cases of von Recklinghausen's disease, 2 of giant cell tumor, 7 of osteoclastoma and 4 of epulis.

*Vascular Neoplasms.*—*Angioma*: Zadek<sup>172</sup> reports data on a case of angioma of the tibialis anterior muscle in a girl of 14 years. She had had pain when walking and tenderness over the region of the growth but no other symptoms. Roentgenographic study gave negative results. The whole width of the muscle was transected above and below the tumor. Healing was uneventful, and complete function of the muscle returned.

*Hemangioma*: Bruno<sup>173</sup> reports data on a case of hemangioma of a vertebra and states that hemangiomatous processes occur in 10 per cent of vertebral columns but do not often cause compression of the cord. The clinical syndrome is not characteristic, and the severity of it depends on the degree of compression. Roentgenographic examination reveals a vertical striated appearance in the body of the vertebra and a honeycombed rarefaction in the pedicles and laminae. It is estimated that a third of the body must be involved before roentgenologic diagnosis is possible. He states that his patient had obtained considerable relief following roentgen therapy up to the time of his report.

172. Zadek, I.: Angioma of the Tibialis Anterior: A Case Report, *J. Bone & Joint Surg.* 25:930-931 (Oct.) 1943.

173. Bruno, F. E.: Hemangioma of the Vertebrae: Report of a Case, *Bull. New England M. Center* 5:237-239 (Oct.) 1943.

Blackford<sup>174</sup> also reports data on a case of hemangioma of a vertebra in which there was compression of the cord and in which a cure after fourteen years' duration had been obtained following roentgen therapy. He states that hemangioma of a vertebra is seen in more than 10 per cent of routine autopsies and occurs more frequently in older persons and women. It causes symptoms relatively often in young men. Radiation is advised by most doctors, as surgical treatment carries too high a mortality rate. He states that his patient had an extremely vascular tumor which was diagnosed pathologically as probable osteogenic sarcoma of telangiectatic type. The patient received roentgen therapy and was relieved from his symptoms. Therefore, clinically this was a hemangioma of a vertebra. The patient was accepted by the army fourteen years subsequently.

Kaplan<sup>175</sup> reports data on a case of hemangioma of the elbow in which treatment by means of radium was given at an early age. The patient, an infant aged 10 weeks, had a large hemangioma over the outer and the inner surface of the elbow. Radium treatment was given, and the patient was followed for nine years. There was no clinical or roentgenologic evidence of any deleterious effect on the centers of growth or on the function of the joint. The author concludes that fear of adversely affecting growing bones of children with radium therapy is fallacious if irradiation is properly and expertly administered.

Cobey<sup>176</sup> discusses data on 4 cases of hemangioma of the knee joint. He draws attention to the fact that this is not a rare condition and should be considered in any case in which swelling of the knee joint is a presenting symptom. The presence of other hemangiomas on the body, intermittent swelling of the knee with decrease in swelling on elevation of the limb point to the probability of this type of tumor of the joint. The tumor may be in the synovial membrane or the capsule. Treatment is surgical excision if the lesion is small or roentgen therapy if it is extensive. He expresses the belief that biopsies of all tumors of this type should be taken for diagnosis and before roentgen therapy is given.

174. Blackford, L. M.: Hemangioma of Vertebra with Compression of Cord: Report of a Case Cured with Radiation Fourteen Years Ago, *J. A. M. A.* 123:144-146 (Sept. 18) 1943.

175. Kaplan, I. I.: Hemangioma of the Elbow Successfully Treated with Radium at an Early Age, *Am. J. Dis. Child.* 65:785-787 (May) 1943.

176. Cobey, M. C.: Hemangioma of Joints, *Arch. Surg.* 46:465-468 (April) 1943.

[ED. NOTE.—Benign angiomas are radiosensitive, and repeated exposure to roentgen rays at regular intervals for months appears to be a satisfactory method of treatment. Microscopic examination and the opinion of an expert pathologist are advisable in those cases in which biopsy does not entail any great danger to the patient.]

**Ewing's Sarcoma:** In a report on the roentgenologic aspects of Ewing's sarcoma of bone marrow Swenson<sup>177</sup> states that there is great variation in its roentgenologic manifestations and hence there is no typical roentgenologic picture and a definite diagnosis can rarely be made from roentgenographic examination alone. The disease may spread from the site of primary involvement throughout the soft tissue of the marrow cavity without producing destruction of bone, which would betray its entire extent. Evidence suggests that a combination of surgical and roentgen therapy will give the best results with this type of lesion.

[ED. NOTE.—I am inclined to agree with this author that there is no typical roentgenographic picture of Ewing's sarcoma. I have pointed out that the roentgenographic findings are frequently confused with those in osteomyelitis. While the microscopic interpretation by the pathologist is advisable for lesions of this type, the lesion is radiosensitive, and diagnostic irradiation may be employed.]

Stout<sup>178</sup> presents a discussion of the pathologic features and the histogenesis of Ewing's tumor of bone marrow. The principal pathologic features of this lesion of the bone marrow are given, and the hypotheses of Ewing, that the tumor is derived from vascular or perivascular endothelium, and of Oberling, that it is derived from young reticular cells, are discussed. Although the author favors the latter hypothesis, he believes that no conclusions regarding histogenesis are possible with the present knowledge.

Muscolo<sup>179</sup> discusses the difficulties encountered in the diagnosis of Ewing's tumor and osteomyelitis. The roentgenologic findings in Ewing's sarcoma during the early stages of the disease are similar to those in subacute and chronic osteomyelitis. After the initial period of reaction Ewing's tumor could be confused with acute osteomyelitis. Biopsy must be performed in all

cases, because the clinical and the roentgenographic findings are not sufficient to rule out either one definitely. For a tumor of the body of a vertebra the true nature of which is doubtful, he uses the puncture biopsy, according to the technic of Valls, Ottolenghi and Schajowiz.

Beck<sup>180</sup> presents a report concerning Ewing's sarcoma and points out that the diagnosis is based mainly on the clinical and the roentgenologic symptoms rather than on a circumscribed histologic appearance. Furthermore, he feels that there exist different opinions about the histogenesis of this type of tumor, which is expressed in various names, like angioendothelioma, diffuse endothelioma, reticuloendothelioma and primary lymphoma of bone. The author then describes his observations in 5 cases of Ewing's sarcoma with a rosette-like structure of the tumor cells. All the sarcomas showed the same picture: There was a group of radially arranged cells with the cytoplasm toward the center. The cytoplasm had a fine granular appearance, containing fine collagen fibers and droplet formation. All of his cases were proved instances of the Ewing type of sarcoma. On the basis of his observations, the author points out the bearing of the rosette-like structure on the hitherto various opinions of the histogenesis of these tumors. On this basis they are not endothelioma, lymphoma nor reticuloendotheliosarcoma. However, it is also impossible to come to an explanation of the histogenesis with the foregoing microscopic observations. The possibility of the tumor's being an immature osteoblastosarcoma is mentioned. The question arises whether the clinical and roentgenologic picture of Ewing's sarcoma may exist with histologically different tumors. There is no definite answer, but it is more likely that Ewing's sarcoma represents a clinical, roentgenologic and histologic circumscribed symptom complex.

Barden<sup>181</sup> discusses the similarity of the clinical and roentgenologic features of Ewing's sarcoma and sympathetic neuroblastoma as observed in children and reports data on 4 cases, in 2 of which the tumor was Ewing's sarcoma and in 2 sympathetic neuroblastoma. There was roentgenologic evidence of widespread tumor of bone, and it was clinically impossible to make a differential diagnosis preceding death of the patients.

177. Swenson, P. C.: The Roentgenologic Aspects of Ewing's Tumor of Bone Marrow, *Am. J. Roentgenol.* 10:343-353 (Sept.) 1943.

178. Stout, A. P.: A Discussion of the Pathology and Histogenesis of Ewing's Tumor of Bone Marrow, *Am. J. Roentgenol.* 50:334-342 (Sept.) 1943.

179. Muscolo, D.: Sarcoma de Ewing y osteomielitis. Dificultades de diagnostico, *Rev. Asoc. méd. argent.* 57:599-603 (Aug. 30) 1943.

180. Beck, W.: Ueber das Vorkommen rosettenartiger Bildungen in Knochensarkomen von der Art des sog. Ewing-Sarkoms, *Virchows Arch. f. path. Anat.* 308:750-775, 1942.

181. Barden, R. P.: The Similarity of Clinical and Roentgen Findings in Children with Ewing's Sarcoma (Endothelial Myeloma) and Sympathetic Neuroblastoma, *Am. J. Roentgenol.* 50:575-581 (Nov.) 1943.



A solitary tumor of bone diagnosed as Ewing's sarcoma should be treated as if the lesion were secondary to an abdominal tumor, whether the presence of the latter can be proved or not. Accordingly, amputation for cure should probably not be attempted and roentgen therapy to the retroperitoneal structures should be routine.

**Malignant Osteogenic Sarcoma.**—MacDonald and Budd<sup>182</sup> present a review of data on 118 cases of osteogenic sarcoma in which five year cures were obtained from the Registry of Bone Sarcoma. In 1941 the Registry of Bone Sarcoma reported 1,022 registered cases of "osteogenic" sarcoma. In 654 cases the lesion had been treated five years or more prior to 1941 and in only 97, or 14.8 per cent, were five year cures obtained. One hundred and fifteen instances of chondrosarcoma, with 21 five year cures (11 per cent), had been found in the Registry, with other cases of chondrosarcoma undoubtedly remaining unidentified without a complete survey of the entire collection. This group of 118 cases of a highly lethal type of neoplasm in which five year cures had been obtained offered a challenge to a critical review of the clinical and microscopic features and of the methods by which the lesions had been treated. It was anticipated that differences might be found in a comparison of a series of cured lesions with a series of uncured lesions, to be unselected except for a comparable regional incidence. Through the cooperation of the Registry it was possible for them to study the case records, the roentgenograms and the microscopic slides of the entire group of cured lesions, but the present emergency interrupted the study, with only 47 cases of fatal osteogenic sarcoma reviewed.

They present two tables which give the classification of the Registry of Bone Sarcoma for 1923 and for 1939 and suggest a modification, as follows:

Malignant		Benign	
Osteo- genic series	(a) Osteosarcoma	Osteogenic sarcoma	Osteoma
	(b) Chondrosarcoma		Chondroma
	(c) Fibrosarcoma		

Several illustrative photomicrographs are shown.

[ED. NOTE.—These authors have again introduced the term "osteosarcoma," which had been discarded in recent years by the Registry and other authorities, and have employed it to signify sarcoma characterized by production of bone. They employ "osteogenic sarcoma" as a generic

designation for the triad of connective tissue sarcomas primary in bone, the third member of which is chondrosarcoma. They state that analysis of the results in osteogenic sarcoma indicates that true osteosarcoma is an almost uniformly fatal form of neoplasm, that fibrosarcoma is a distinctly less malignant form of osteogenic sarcoma and that chondrosarcoma occupies a median position, being cured in approximately equal proportions.]

Luck<sup>183</sup> presents an excellent roentgenologic and microscopic pathologic review of neoplasms which produce bone or cartilage. He includes osteoma, chondroma, osteochondroma and malignant types osteogenic sarcoma and chondrosarcoma. He discusses modern beliefs on surgical treatment and experiences regarding treatment.

Pomeranz<sup>184</sup> presents a paper on the roentgenographic diagnosis of osteogenic sarcoma. He gives the criteria for the roentgenologic diagnosis and the differential diagnosis. He emphasizes the fact that the roentgenogram should be interpreted in relation to the clinical findings and the history. He states that statistically 90 per cent of these lesions occur in the long bones of the lower portion of the limb and 10 per cent in the upper part of the limb and that the disease is essentially one of youth. The osteolytic type of tumor grows more rapidly than the osteoblastic. The tumors as a group produce simultaneous destruction of bone and bizarre formation of new bone.

**Chondrosarcoma:** Lichtenstein and Jaffe<sup>185</sup> present a discussion of chondrosarcoma of bone. In comparison with osteogenic sarcoma, chondrosarcoma is less common, appears at a later age and is slower to metastasize to the lungs. In the former the basic proliferating connective tissue merges directly into neoplastic osteoid tissue and bone, although cartilage may be formed. In the latter the basic proliferating tissue is unfledged cartilage, although the matrix may become calcified and ossified. Early chondrosarcoma may be diagnosed microscopically if the definite signs of malignant growth are looked for carefully. They are (1) many cells with plump nuclei, (2) more than an occasional cell with two such nuclei and (3) giant cartilage cells with large single or multiple nuclei or with clumps.

183. Luck, J. V.: A Correlation of Roentgenographic and Pathological Changes in Ossifying and Chondrifying Primary Osteogenic Neoplasms, *Radiology* 40:253-259 (March) 1943.

184. Pomeranz, M. M.: The Roentgenographic Diagnosis of Osteogenic Sarcoma, *Bull. Hosp. Joint Dis.* 4:3-11 (April) 1943.

185. Lichtenstein, L., and Jaffe, H. L.: Chondrosarcoma of Bone, *Am. J. Path.* 19:553-559 (July) 1943.

182. MacDonald, I., and Budd, J. W.: Osteogenic Sarcoma: I. A Modified Nomenclature and a Review of 118 Five Year Cures, *Surg., Gynec. & Obst.* 77:413-421 (Oct.) 1943.

chromatin. It can often be proved that a chondrosarcoma has developed from a benign lesion, either an enchondroma or an osteochondrogenous exostosis (osteochondroma). In their paper they present studies of cases, photographs of gross lesions and roentgenograms and microscopic views of 10 central and 5 peripheral chondrosarcomas. Chondrosarcoma spreads late, and when it does spread it is usually via the venous channels by intravascular growth and extension, though it often gives rise to parenchymal metastatic growths, usually only to the lungs. In determining the malignancy of a chondroma, attention should be paid to regions which are amorphous and not heavily ossified or calcified. Since cell division in chondrosarcoma tends to be amitotic, search for mitotic figures is not extremely important. Roentgenologic signs of malignancy in an enchondroma are an irregularly mottled and calcified shadow in the interior of the bone and a fuzzy area of localized destruction of the cortex. Malignant changes in an osteochondroma are indicated by a dense, blotchy appearance, usually with ragged, irregular, dense streaks extending away from the lesion. Radical surgical treatment is recommended; irradiation is not.

**Osteoclastoma.**—Brailsford<sup>186</sup> considers the treatment of osteoclastoma to be primarily roentgen irradiation. He believes that biopsy is not necessary, since the diagnosis can be made by roentgenography. He suggests that roentgen therapy be given before amputation, if amputation is deemed necessary.

**Sarcoma of Patella.**—Bowen<sup>187</sup> reports an unusual case of primary tumor of the patella. At autopsy the tumor was classified as a sarcoma, and the author believes that it might have developed from a giant cell tumor.

**Primary Malignant Tumor of Bone.**—Shallow, Raker and Fry<sup>188</sup> analyze data on 53 cases of primary malignant tumor of bone observed at the Jefferson Medical College Hospital over twenty years. This series consisted of 43 cases of osteogenic sarcoma, 4 of Ewing's sarcoma, 1 of multiple myeloma and 1 each of adamantinoma, liposarcoma and probably malignant giant cell tumor. In 6 (18.7 per cent) of the 33 cases of osteogenic sarcoma in which adequate operation could be performed the patients survived

five years; amputation was the most frequent type of treatment employed; roentgen and radium therapy and Coley's toxins (a mixture of erysipelas and *Bacillus prodigiosus* toxins) were also employed, with or without surgical treatment; in 18 cases amputation alone was performed. In 8 cases in which the patients lived, the longest period of survival was twelve and a half years. A brief history of these cases is presented.

All 4 of the patients who had Ewing's sarcoma died. One of them died postoperatively, and in 3 metastasis developed, resulting in death. One patient who had adamantinoma had noticed the lesion after trauma to the tibia. Amputation was performed on this patient, and death occurred twenty-two months following the onset of symptoms. Sixteen cases of giant cell tumor were studied, in which treatment was varied and consisted of operation, roentgen therapy or a combination of operation and roentgen therapy. In 1 of these cases the tumor was considered malignant and astragalectomy was performed; the patient was living seven years later.

The authors found a high incidence of trauma and believe it "seems to play some role in the genesis of bone tumors." They stress the danger of diagnostic biopsy and believe arteriography a great diagnostic aid, quoting Inclan. They believe that when amputation is indicated it should be performed at the "earliest optimum time, rather than as soon as the diagnosis has been made."

[ED. NOTE.—The difficulties in attempting to arrive at definite scientific conclusions from a study of a limited number of cases of tumors of various types is obvious.]

**Osteogenic Sarcoma of the Vertebrae Secondary to Paget's Disease.**—Campbell and Whitfield<sup>189</sup> present data on 3 cases of osteogenic sarcoma of the vertebrae in patients suffering from Paget's disease. In all 3 cases the condition was characterized by increasingly severe backache of short duration with neurologic changes in the lower part of the trunk and in the extremities. Careful search of the literature by the authors revealed but 3 cases of sarcoma of the vertebrae. In all of these there was involvement of other bones, so that it was difficult to determine the primary lesion. On the other hand, their search revealed an incidence of osteogenic sarcoma of various bones in Paget's disease of 7.5 to 14 per cent, according to differ-

186. Brailsford, J. F.: Treatment of Osteoclastoma, *Ann. Surg.* 1:776-777 (June 19) 1943.

187. Bowen, F. H.: Sarcoma of the Patella: Report of a Case, *J. Florida M. A.* 30:20-22 (July) 1943.

188. Shallow, T. A.; Raker, N., and Fry, K.: Primary Malignant Tumors of Bone with Special Reference to Osteogenic Sarcoma, *J. Internat. Coll. Surgeons* 6: 98 (March-April) 1943.

189. Campbell, E., and Whitfield, R. D.: Osteogenic Sarcoma of Vertebrae Secondary to Paget's Disease: Report of Three Cases with Compression of Spinal Cord and Cauda Equina, *New York State J. Med.* 43:931-938 (May 15) 1943.

ent authors. Radiation or surgical treatment of such tumors produces little or no improvement. In 2 cases in this series the patients underwent operation and died four or five months later. In the other case the patient refused operation and died four months after the onset of symptoms.

*Aneurysm Simulating Malignant Tumor.*—Kirshbaum and Kraft<sup>190</sup> present data on an unusual aneurysm which simulated a malignant tumor of bone in that there was destruction of the upper portion of the fibula by pressure from the aneurysm of the tibial artery and tumefaction of the soft tissue. The correct diagnosis was made at necropsy. The clinical and roentgenologic diagnosis was osteolytic sarcoma of the fibula.

*Development of Bone in Relation to Formation of Neoplasms.*—Haldeman<sup>191</sup> presents a paper on the development of bone in relation to the formation of neoplasms. He reiterates the findings of Geschickter and Copeland and gives their classification of tumors of bone. A discussion by Bromer includes the part trauma plays in the genesis of periosteal and osseous tumors.

*Multiple Myeloma.*—Toth and Wintermantel<sup>192</sup> review the general features of solitary myeloma and give data on a case of an apparent solitary myeloma of the right pubic bone with local expansion and subsequent generalization. Histologically it was a plasma cell type of myeloma. There was improvement following roentgen therapy, contrary to the general opinion as to the value of roentgen therapy for this condition.

*Metastatic Tumors.*—Koenig and Culver<sup>193</sup> discuss the value of roentgen therapy for carcinomatous metastasis to bone and believe that surgeons and clinicians lack enthusiasm for the use of roentgen therapy when a patient manifests metastasis to bone. The results obtained are alleviation of pain, improvement of general con-

dition, prolongation of life and regression of lesion.

Cleveland and Knox<sup>194</sup> present a case of lateral carcinoma of the adrenal cortex with metastasis to the iliac bone in a man aged who complained of pain in the right hip with extension into the leg. The pain had followed an injury which had occurred six months before. There had been loss of weight. A punch biopsy had been done and a diagnosis of tumor made. The roentgenograms revealed a destructive lesion of the right iliac bone; the pulmonary fields were clear. In an exploratory operation tissue was removed from the iliac crest; frozen sections were examined and reported as probable sarcoma. A high temperature developed; however, no bleeding from the wound occurred. The patient was treated for shock. He remained unconscious until death occurred, on the second postoperative day.

Necropsy showed the following picture: The adrenals were both practically destroyed and had been replaced by thinly encapsulated tumor masses, the right being 7 by 7 by 5 cm. and the left slightly smaller. They were entirely distinct from the kidneys and adjacent fat. In the anterior part of the right iliac bone the hemorrhagic cavity formed by the removal of tissue for biopsy was found filled with blood clots. The adjacent bone was soft, friable and obviously infiltrated by tumor over an area 4 by 6 cm. Outside the bone large, soft lobulated masses of tumor extended down through the gluteus medius muscle. Here the growth was white, opaque and homogeneous except for a few hemorrhagic regions. The diagnosis was bilateral adrenal carcinoma; metastasis to the right iliac bone and adjacent muscles; adenoma of the right kidney, and bronchopneumonia.

The authors also present a review of the literature. They give a summary of 49 cases reported. In these 49 cases 18 of the tumors occurred in men, 23 in women and 8 in children. In 5 cases the tumors were bilateral. In 40 of these 49 cases the authors were reasonably certain of the site of origin; 14 tumors had been primary on the right side and 26 on the left. They state that the prognosis is poor; the tumor metastasizes by way of the blood stream and grows rapidly. There is a high mortality following operation. Of a total of 40 patients who underwent operation, 50 per cent died shortly thereafter, usually within forty-eight hours. Metastasis, as shown by 18 necropsies,

190. Kirshbaum, J. D., and Kraft, G. L.: Traumatic Arteriosclerotic Aneurysm of the Tibial Artery Simulating an Osteogenic Sarcoma of the Fibula: Case Report, *Ann. Surg.* **117**:793-797 (May) 1943.

191. Haldeman, K. O.: Development of Bone in Relation to the Formation of Neoplasms, *Radiology* **40**:247-251 (March) 1943.

192. Toth, B. J., and Wintermantel, J. A.: An Apparently Solitary Myeloma of Bone with Subsequent Generalization: Favorable Response to Irradiation with Unusual Reactions, *Radiology* **41**:472-477 (Nov.) 1943.

193. Koenig, E. C., and Culver, G. J.: The Value of Roentgen Therapy in Carcinomatous Metastases to Bone, *Radiology* **41**:38-41 (July) 1943.

194. Cleveland, M., and Knox, L. C.: Bilateral Carcinoma of the Adrenal Cortex with Metastasis to the Iliac Bone, *Arch. Surg.* **47**:192-202 (Aug.) 1943.

urred most frequently in the lungs, liver and lymph nodes.

Toumey<sup>195</sup> discusses metastatic malignant lesions of the spinal column and reviews data on patients seen at the Lahey Clinic from 1936 to 1940 with roentgenographic evidence of metastasis. Spinal metastasis was twice as prevalent among female as among male patients; it was usually the result of carcinoma of the breast or prostate, other sources being unusual. He believes that roentgenographic examination should be performed in all cases in which the patient has pain in the back and that roentgen therapy could be employed if there is clinical spinal metastasis, even when the roentgenograms are reported normal. He believes that roentgen therapy is the most valuable treatment and that results following the use of cobra venom have been disappointing. Chordotomy and subarachnoid injection of alcohol are valuable in cases in which the patient has intractable pain. Orchiotomy is of value in treating carcinoma of the testis. Braces, salicylates, codeine and, in cases in which the disease has reached the later stages, dihydromorphinone hydrochloride are helpful adjuvants.

Sinberg<sup>196</sup> reports an interesting case of metastasis to a metacarpal bone from a carcinoma of the testicle. The destructive lesion was situated in the fourth metacarpal bone of a man 45 years of age. The roentgenographic diagnosis was a malignant lesion, and several pathologists reported that the tissue showed wing's sarcoma. There was regression of the tumor with roentgen therapy, but later a tumor of the left testicle was discovered, and orchiectomy was performed. On comparison, the tissue from the metacarpal bone and from the testicle was identical, and a diagnosis of carcinoma was made. Still later a mass developed in the right tibia, which showed regression following roentgen therapy.

*Epidermoid Carcinoma of the Tibia.*—Kraft<sup>197</sup> reports data on 2 interesting cases of epidermoid carcinoma of the tibia with pathologic fractures. Amputation was performed with the limb under refrigeration anesthesia. One lesion arose from a chronic ulcer and one from a fistula or an osseous sinus. In his review of the literature

he found the tibia the most frequent location of this lesion. Ulcer carcinoma occurs most frequently among women, while fistulous carcinoma is observed most frequently in men of advanced age and in persons with osteomyelitis of thirty to forty years' duration. He believes that amputation usually is indicated and that the prognosis is favorable. He refers to an article by Dockerty and Meyerding in which they discuss adamantinoma and conclude:

The fact that adamantinoma is closely related to the epidermoid carcinoma finds further corroboration in the following common characteristics: (1) Long history of chronic irritation with episodes of either initial or aggravating trauma. (2) Sites of predilection in the tibia, jaw bones and skull. (3) Development in a bone cyst or osseous sinus. (4) Tendency to remain localized and absence of distant metastases in most cases.

*Comments and Queries on Primary Benign and Malignant Tumors of Bone.*—Meyerding<sup>198</sup> presents his classification of lesions simulating neoplasms and true neoplasms of bone. He further lays emphasis on the value of the material accumulated by the Registry of Bone Sarcoma of the American College of Surgeons and by the larger medical centers. Conclusions of real value can be drawn only from records which provide facts concerning the history and the clinical and laboratory findings together with the surgical, microscopic and postoperative data and which contain all the essential information. He appreciates the value of clinical and roentgenologic findings and states that experience has shown that the correct diagnosis and the gravity of the prognosis may not be recognized in some cases from these findings alone. In spite of the surgeon's and the pathologist's best efforts erroneous diagnosis may be made and the true nature of the lesion not discovered until death and necropsy. The close cooperation of the physicians in the various fields of medicine, in surgery and in the laboratory is necessary in arriving at an accurate diagnosis and in giving the patient maximal benefit. The bulk of the paper is concerned with a series of questions and answers. Frank replies are given, and the factors that influence the diagnosis and the prognosis and the value of various forms of treatment of tumors of bone are discussed. Seven illustrative cases with roentgenograms are presented.

*Diagnosis in Primary Tumors of Bone.*—Carrell<sup>199</sup> emphasizes the necessity of the routine examination: complete history of illness, ade-

195. Toumey, J. W.: Metastatic Malignancy of the Spine, *J. Bone & Joint Surg.* 25:292-305 (April) 1943.

196. Sinberg, S. E.: Metastasis to a Metacarpal Bone from a Carcinoma of the Testicle, *Bull. Hosp. Joint Dis.* 31:35 (April) 1943.

197. Kraft, E.: Epidermoid Carcinoma of the Tibia: Report of Two Cases, *Am. J. Roentgenol.* 50:602-608 (Nov.) 1943.

198. Meyerding, H. W.: Comments and Queries on Primary Benign and Malignant Tumors of Bone, *S. Clin. North America* 23:1012-1029 (Aug.) 1943.

199. Carrell, W. B.: Diagnosis in Primary Bone Tumors, *Texas State J. Med.* 39:289-290 (Sept.) 1943.

quate roentgenograms, laboratory studies and biopsy. He feels that biopsy should be performed by a pathologist who is interested in tumors and is equipped to make his report from frozen sections. No harmful effects have been observed in cases in which operation is delayed after biopsy so that the entire specimen may be studied, if such a procedure is deemed advisable. He presents data on 3 cases.

*Treatment.*—Coley<sup>200</sup> discusses indications for surgical treatment of tumors of bone. He believes that surgical treatment should be primarily conservative for the following benign lesions: (1) solitary osteitis fibrosa cystica; (2) giant cell tumors in accessible locations, for which roentgen therapy is not preferred by this author; (3) osteochondroma; (4) central chondroma, which tends to recur and to become malignant, lesions in the phalanges being exceptions, and (5) myxoma and xanthoma. Conservative surgical treatment is occasionally justifiable for the following growths: (1) parosteal osteogenic sarcoma or sarcoma beginning in osteochondroma; (2) tumors of the scapula of low grade malignancy, and (3) tumors involving a metacarpal bone or a phalanx in the hand or foot. Radical surgical treatment is advisable for malignant lesions. Amputation or disarticulation should be performed early, before metastasis has occurred. He believes that histologic proof by aspiration biopsy should be obtained first and that presurgical roentgen therapy is justifiable only when permission for amputation has not been given. Amputation for osteogenic sarcoma proximal to involved bone is advisable except when the lesion is located in the femur. He states that there were no five year cures in those cases in which there was involvement of the upper part of the femur and believes that an amputation through the upper portion of the thigh is indicated and justifiable when there is involvement of the lower part of the femur. Furthermore, he advocates interscapulothoracic disarticulation in those cases in which a tumor is located in the upper part of the humerus. He states that the prognosis for endothelioma is poor; Coley's mixed erysipelas and B prodigious toxins may help. Reticulum cell sarcoma of bone is radiosensitive, and perhaps immediate amputation is not necessary. Liposarcomas are somewhat radiosensitive, although amputation is necessary.

Martin<sup>201</sup> presents a discussion of roentgen treatment of tumors of bone and recognizes the

limitation of this form of treatment. He gives data on 4 cases and concludes: "Irradiation therapy, although it seldom produces a complete cure, plays a very important role in the treatment of bone tumors, particularly those arising from the bone marrow and the lymphatic system."

*Role of the Chemical Laboratory in Diagnosis of Neoplastic Disease of Bone.*—Woodard<sup>202</sup> presents a review of the procedures for and the normal values of common laboratory tests used in diagnosis of tumors of bone and non-neoplastic diseases which may be confused with them. The procedures include determination of serum calcium, phosphorus (inorganic), protein and acid and alkaline serum phosphatase; a urinary test for Bence Jones protein, and the Sulkowitch test. She discusses differential diagnosis on the basis of chemical findings.

*Experimental Study of the Effect of Estrone.*—Miller, Orr and Pybus<sup>203</sup> present a report on the effect of estrogen (estrone) on the skeleton of the mouse, with particular reference to the Newcastle bone tumor (NBT) strain. As a result of a sex difference in the incidence of spontaneous tumors of bone in the NBT strain (more in females than in males) estrone was administered to mice of this strain and to mice of three other strains with a low incidence of bone tumors. Bones of the hindlimbs of untreated NBT females showed, in general, quiescent hyperplasia, this being absent if oophorectomy had been done at an early age. Implantation of massive doses of estrone into young NBT males caused intense osteoclastic activity with some formation of bone; similar changes but less complete, occurred in adult males; with smaller doses of estrone there were correspondingly less changes and more production of bone. Similar changes, but much less quantitatively, occurred in young males of other strains, which indicates some resistance to estrone. The induced lesions were reversible. Administration of estrone did not in itself give rise to sarcoma, but estrone is thought to be an adjuvant agent when the determining factor or factors are present.

[ED. NOTE.—The grade of malignancy is an important factor in determining the prognosis and treatment of tumors of bone. There is an obvious need for more trained pathologists and

202. Woodard, H. Q.: Role of the Chemical Laboratory in Diagnosis of Neoplastic Diseases of Bone. *Arch. Surg.* 47:368-383 (Oct.) 1943.

203. Miller, E. W.; Orr, J. W., and Pybus, F. C.: The Effect of Estrone on the Mouse Skeleton. Particular Reference to the Newcastle Bone Tumor (NBT) Strain. *J. Path. & Bact.* 55:137-150 (Aug.) 1943.

200. Coley, B. L.: Indications for Surgery in Bone Tumors. *Texas State J. Med.* 39:290-293 (Sept.) 1943.

201. Martin, C. L.: X-Ray Treatment of Bone Tumors. *Texas State J. Med.* 39:285-288 (Sept.) 1943.

have made a special study of the interpretation of malignant lesions of bone. The evaluation of various methods of treatment should be correlated with the grade of malignancy (Broders). I do not believe that the results of treatment can

be scientifically appraised unless the exact type and grade of malignancy have been determined in each case. The expert pathologist's opinion of the grade of malignancy in such instances is of the greatest aid to the surgeon.]

## VI. CONDITIONS INVOLVING THE SHOULDER, NECK AND JAW

PREPARED BY JOHN G. KUHN, M.D., BOSTON

*Pathologic Conditions of the Shoulder.*—In 1943 there were a number of papers which increased knowledge of the pathologic features of certain lesions about the shoulder.

Wilson<sup>204</sup> reviews the pathologic conditions of the tendinous attachments about the shoulder, particularly calcification and degeneration of the tendons. This paper gives a complete bibliography.

Wilson and Duff,<sup>205</sup> in a later paper, studied the gross and microscopic pathologic features of both shoulders in 90 adult bodies at autopsy and in 35 cadavers in the dissection room. All but 17 of the bodies were over 30 years of age. Complete rupture of the supraspinatus tendon was found in 9 of 34 cadavers. In the entire group, the incidence of complete rupture was 22.2 per cent with an average age of 65 years. They found that the frequency of rupture increased with age. A tear of the innermost fibers which included the joint capsule gave an apparent increase in the length of the tendon. A rupture of the tendon of the long head of the biceps muscle occurred in 7.4 per cent of the bodies. It frequently follows a rupture of the supraspinatus tendon. They believe that weakening of the supraspinatus tendon always precedes the rupture; a normal tendon does not rupture. Various degenerative lesions are described, which showed histologically alteration in the structure of the tendon, change in staining qualities, increase in the number of arterioles and alteration at the insertion of the tendon. The authors suggest that these degenerative changes are related to age and to injuries and occur in all parts of the body.

Lippmann<sup>206</sup> studied the pathologic changes in 12 "typical" cases of frozen shoulder at operation. He offers evidence to show that the chief lesion in so-called "periartthritis" of the shoulder

is a bicipital tenosynovitis. This he believes to be the most common ailment in the region of the shoulder. The sheath of the long head of the biceps muscle is not a true sheath, in that it is closed only at one end, nor does the biceps tendon slide in its sheath. The greatest movement of the biceps tendon occurs in external rotation. The common cause of frozen shoulder or periartthritis is an inflammation in this sheath. When the inflammation subsides the tendon becomes fixed to the surrounding tissues, and pain subsides. The author found tenosynovitis of the tendon of the long head of the biceps muscle in every patient who was operated on. He believes that surgical operation is justifiable during the acute stage to obliterate the tendon sheath mechanism. To accomplish this the tendon should be sutured to the lesser tuberosity, with the arm in abduction and external rotation. Manipulation is not beneficial. Rest is suggested as the best treatment, since symptoms disappear if the tendon becomes fixed. The disability never recurs.

In the treatment of inflammation of the subdeltoid bursa, Brewer and Zink<sup>207</sup> suggest roentgen therapy as the best treatment of acute subdeltoid bursitis. A single dose of 300 r may suffice to relieve symptoms. This dose may be repeated if necessary in seven to ten days. Often there is an aggravation of pain for eight to twenty-four hours following radiation. The residual tenderness disappears in a few days. Of 14 patients 11 were completely relieved and returned to work in forty-eight hours. Radiation therapy was less effective for chronic bursitis. Only 30 per cent of the patients with chronic bursitis received benefit from the treatment. When no improvement occurs in forty-eight hours, the authors believe that operative treatment should be considered. The experience of Harris<sup>208</sup> is similar. He reports the results of treatment of 40 patients with acute subdeltoid bursitis with roentgen rays. Three or four treatments of 250 r were given daily. Relief of pain occurred in twenty-four to

204. Wilson, C. L.: Lesions of Supraspinatus Tendon: Degeneration, Rupture and Calcification, Arch. Surg. 46:307-325 (March) 1943.

205. Wilson, C. L., and Duff, G. L.: Pathologic Study of Degeneration and Rupture of the Supraspinatus Tendon, Arch. Surg. 47:121-135 (Aug.) 1943.

206. Lippmann, R. K.: Frozen Shoulder; Periartthritis; Bicipital Tenosynovitis, Arch. Surg. 47:283-296 (Sept.) 1943.

207. Brewer, A. A., and Zink, O. C.: Radiation Treatment of Acute Subdeltoid Bursitis, J. A. M. A. 122:800-801 (July 17) 1943.

208. Harris, J. H.: Roentgen Treatment of Acute Bursitis of Shoulder, Pennsylvania M. J. 46:683-684 (April) 1943.

thirty-six hours. Normal use returned in about ten days.

[ED. NOTE.—Roentgen therapy for acute bursitis is useful, but in my experience this form of therapy alone brings relief of symptoms in only about a third of the patients treated. It must frequently be supplemented by other forms of therapy.]

Lapidus<sup>209</sup> reports the results of infiltration therapy in 34 patients with tendinitis with calcification. His technic was as follows: The tender spot over the tendon of the long head of the biceps brachii muscle was infiltrated with 10 to 20 cc. of a 1 per cent solution of procaine hydrochloride. The surrounding area was then infiltrated with 30 to 60 cc. of warm isotonic solution of sodium chloride after a roentgenogram showed that the needle was in the area of calcification. This method was used chiefly for tendinitis in the shoulder, but the author found it useful in other regions where inflammation of the tendon was present. Treatment was followed by relief of pain in twenty-four hours usually. After treatment there was gradual disappearance of the deposit. In cases in which there were adhesions or a "frozen shoulder," infiltration was of no value. It was also of questionable value for long-standing tendinitis.

*Dislocation of the Shoulder.*—Hale<sup>210</sup> believes that most dislocations of the shoulder can be reduced by bringing the arm over the head with traction parallel to the long axis of the body. Anesthesia is not usually necessary. For a short time after reduction a cuff is worn about the elbow to prevent wide abduction of the arm.

May<sup>211</sup> reports the use of the Nicola operation in 3 cases of posterior dislocation of the humeral head. The procedure was successful in 2 of them. In the other the proximal end of the long head of the biceps muscle became stretched. The redislocation was repaired by a fascial sling.

A review of the tenosuspension operation for recurrent dislocation of the shoulder is presented by Henderson.<sup>212</sup> Fifty-five operations were performed on 51 patients. The peroneus longus tendon is split, and half of the tendon is removed for the tenosuspension. The patients remain in

bed ten days after operation, when physical therapy is begun. Ninety-one per cent of the patients were cured by this operation. Five patients had dislocations subsequent to the operation. Three of these were subject to epilepsy and in 2 the tendon was too short. If the dislocation is going to recur, it will take place within one year of operation.

*Other Conditions About the Shoulder.*—Oppenheimer<sup>213</sup> believes that arthritis of the acromioclavicular joint is fairly common. It demonstrated most easily in roentgenograms showing anteroposterior views, with the patient upright and holding the shoulder back. The symptoms are indistinguishable from those of other lesions in this region. Roentgen therapy in small doses, is an effective method of treatment.

[ED. NOTE.—Evidence of arthritic involvement of this joint is frequently seen in roentgenograms. Symptoms are not often found. In most instances it is merely incidental.]

Mazet<sup>214</sup> reports 2 cases in which a Kirschner wire migrated from the shoulder region into the lung. In the first case it followed the insertion of two Kirschner wires for the repair of an acromioclavicular dislocation. Three months later the wire had become embedded in the upper lobe of the right lung. There were no symptoms. The wires were removed, and there were no sequelae. In the second case a shoulder paralyzed from poliomyelitis was fused and three Kirschner wires were drilled through the humeral head into the glenoid. Two months later two wires were removed. The third wire had migrated into the thoracic cavity. It was removed without complication. The author advises using a stop or a nut on Kirschner wires to prevent migration.

Forty-six cases of localized neuritis of the shoulder girdle are reported by Spillane,<sup>215</sup> which he observed while serving as medical officer with the troops in the Middle East. In 26 the neuritis was associated with various afebrile conditions. In 20 it developed while the patient was in the field. Sharp pains in the shoulder were the first symptom in 42. Weakness in muscles followed in four to five days. This weakness was followed by atrophy. In none of the cases did complete recovery occur.

209. Lapidus, P. W.: Infiltration Therapy of Acute Tendinitis with Calcification, *Surg., Gynec. & Obst.* 76:715-725 (June) 1943.

210. Hale, K.: French Method of Reducing Subluxation of the Shoulder, *Ohio State M. J.* 39:1006-1007 (Nov.) 1943.

211. May, H.: Nicola Operation for Posterior Subacromial Dislocation of the Humerus, *J. Bone & Joint Surg.* 25:78-84 (Jan.) 1943.

212. Henderson, M. S.: Tenosuspension Operation for Recurrent or Habitual Dislocation of the Shoulder, *S. Clin. North America* 23:927-945 (Aug.) 1943.

213. Oppenheimer, A.: Arthritis of Acromioclavicular Joint, *J. Bone & Joint Surg.* 25:867-870 (Oct.) 1943.

214. Mazet, R., Jr.: Migration of Kirschner Wire from Shoulder Region into Lung: Report of Two Cases, *J. Bone & Joint Surg.* 25:477-483 (April) 1943.

215. Spillane, J. D.: Localized Neuritis of the Shoulder Girdle: A Report of Forty-Six Cases, *M. E. F., Lancet* 2:532-535 (Oct. 30) 1943.

The serratus anterior muscle was involved in 34 cases, the spinatus muscles in 24, the deltoid muscle in 17 and the trapezius muscle in 11. Other muscles were rarely involved. The nerve lesion was peripheral. Various forms of treatment were employed without success. The cause of the neuritis was unknown.

Dynes<sup>216</sup> observed 2 patients in whom subacromial bursitis developed after the onset of disease of the nervous system without trauma. The first patient was suffering from hemiplegia and the second from Parkinson's disease. Response to treatment of the bursitis was slow, and full recovery did not occur.

*The Neck.*—Semmes and Murphey<sup>217</sup> report cases of unilateral rupture of the sixth cervical intervertebral disk with compression of the seventh cervical nerve root. Three of the patients were men, and 1 was a woman. The duration of symptoms varied from three weeks to seven years. There was a history of numerous catches in the neck preceding pain along the seventh cervical nerve, difficulty in breathing and muscular spasm in the neck. There was tenderness over the root of the seventh cervical nerve. Roentgenograms showed straightening of the cervical portion of the spine. In 1 patient there were narrowing of the intervertebral foramen and slipping. No contrast medium was used in the roentgenographic studies. Operation was performed, with the area under local anesthesia. The protruded disk was small. The total protein content of the spinal fluid was increased in 3 patients. Three patients were operated on; 2 were completely relieved, and 1 had slight persistent pain but was improving with physical therapy. The authors believe that the diagnosis of this condition is often missed and that it is confused with osteoarthritis. They do not think that osteoarthritis produces symptoms in the nerve roots.

A critical discussion of the various hypotheses of the mechanisms causing infringement on cervical nerve roots is given by Hanflig.<sup>218</sup> Methods of diagnosis are described. He outlines his method of traction, maintained with 5 or 10 pounds' (2.3 or 4.5 Kg.) weight on the cervical portion of the spine.

216. Dynes, J. B.: Subacromial Bursitis Associated with Diseases of the Nervous System, *Lahey Clin. Bull.* 124-127 (April) 1943.

217. Semmes, R. E., and Murphey, F.: Syndrome of Unilateral Rupture of Sixth Cervical Intervertebral Disk, with Compression of Seventh Cervical Nerve Root, *J. A. M. A.* 121:1209-1214 (April 10) 1943.

218. Hanflig, S. S.: Pain in the Shoulder Girdle, Arm and Precordium Due to Foraminal Compression Nerve Roots, *Arch. Surg.* 46:652-663 (May) 1943.

Two patients with atlantoaxial dislocation are described by Bull.<sup>219</sup> The first patient was a 60 year old laborer, who complained of difficulty in using his arms and inability to walk following an electric shock one month before. Roentgenograms showed an anterior dislocation of the atlas on the axis with fracture of the odontoid peg. Traction was applied to the neck, after which a Thomas neck splint was used. Symptoms were partially relieved, but improvement was lost when the splint was discarded. The other patient was unable to use his arms and legs. There was dislocation of the axis on the atlas but no fracture of the odontoid peg. No treatment was given.

Intermittent compression of the subclavian artery and vein between the clavicle and the first rib was found in 3 patients by Falconer and Weddell.<sup>220</sup> These patients were examined to determine the effects of postural maneuvers of the shoulder girdle on the pulse. Backward and downward bracing of the shoulders obliterated the pulse readily. The authors found that the pulse in the subclavian vessels could be obliterated by such maneuvers in many normal persons. Symptoms arose only when compression took place easily. This disability was differentiated from the scalenus anticus syndrome by paralyzing the scalenus anticus muscle with a local anesthetic. A fourth patient was found with neurologic symptoms only following such compression. For patients with the milder symptoms remedial exercises to improve the postural tone in the muscles of the shoulder girdle were of benefit. Those with more severe symptoms required operation. This consisted of removal of a segment of the offending rib.

Engel<sup>221</sup> attempts to apply Bonnevie's theory, that pressure from a cerebrospinal fluid bleb is responsible for the development of deformities, to the development of undescended scapula, Klippel-Feil syndrome and symbrachydactylia. He postulates the escape of cerebrospinal fluid through the area membranacea of the fourth ventricle at the time the limb buds for the upper extremities are beginning to appear. From pressure of such cerebrospinal blebs, destruction or delay in development could result in the limb bud and in the spinal column as well. He cites

219. Bull, G. M.: Syndrome of Atlanto-Axial Dislocation, *Clin. Proc.* 1:336-345 (Oct.) 1942.

220. Falconer, M. A., and Weddell, G.: Costoclavicular Compression of Subclavian Artery and Vein, *Lancet* 2:539-543 (Oct. 30) 1943.

221. Engel, D.: Etiology of Undescended Scapula and Related Syndromes, *J. Bone & Joint Surg.* 25:613-625 (July) 1943.



experiments by others in which claw foot, claw hand and polydactylism resulted from similar pressure.

[ED. NOTE.—This is an interesting and intriguing speculation. Much more work must be done to make it a convincing argument.]

*The Jaw.*—Brown and McDowell<sup>222</sup> have found that Kirschner or stainless steel wires drilled through the jaw are helpful in the fixation of fractures of the jaw which cannot be held by interdental wiring. This method is particularly useful in compound fractures, fractures at the angle of the jaw and fractures where there are no teeth for wiring. Since one wire fixes the bones in one plane only, several wires are usually required. In their cases the wires were drilled into the mandible with a power drill. There was little reaction from the wires. Sulfonamide drugs were used locally. The bones were alined by hand and then fixed with the wires. The nerve canal was carefully avoided. The patient remained in the hospital two to three days. The wires were usually removed in three to five weeks.

[ED. NOTE (L. D. B.).—The use of internal fixation in compound fractures may be disastrous, if the nerve canal is not avoided the involved teeth will be killed.]

222. Brown, J. B., and McDowell, F.: Internal Wire Fixation for Fractures of the Jaw: Preliminary Report, *Am. J. Orthodontics (Oral Surg. Sect.)* 29:86-91 (Feb.) 1943.

Smith<sup>223</sup> describes an operation for recurrent dislocation of the jaw. A 1 inch (2.5 cm.) vertical incision is made anterior to the external meatus of the ear. This leaves little scar. A speculum is introduced through this incision and pushed inward until it touches the tuberculum articulare. A 9/64 inch (0.35 cm.) drill is introduced through the speculum and directed cephalad at a 45 degree angle. A bone peg 10/64 inch (0.39 cm.) in diameter is then screwed into the previously drilled hole and left projecting 1/4 inch (0.64 cm.) beyond the tuberculum articulare. This acts as a buffer for the condyloid process. Temporary weakness of the facial nerve sometimes occurs.

The facial bones of 2 men with Paget's disease were studied by Glickman.<sup>224</sup> In 1 patient the disease was found in the right maxilla only. In the other it was found in the maxilla, the mandible and the palatine bones. The changes were like those found in other parts of the body in which Paget's disease was present—areas of degeneration, formation and resorption of bone distributed irregularly in close proximity to each other. There was no characteristic picture which could be identified as Paget's disease. Diagnosis could be made only by studying all of the changes in the bone.

223. Smith, L. D.: Operation for Correction of Recurrent Dislocation of the Jaw, *Arch. Surg.* 46:762-773 (May) 1943.

224. Glickman, I.: Paget's Disease in Maxilla, Mandible and Palate, *Am. J. Orthodontics (Oral Surg. Sect.)* 29:591-607 (Nov.) 1943.

(To Be Continued)

## FRACTURES ABOUT THE ELBOW IN CHILDREN

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It is the purpose of this paper to discuss fractures about the elbow joint in children and to give a brief outline of the various types of fractures, their relative frequency and the method of treatment for each type.

Fractures involving the elbow joint in children are relatively common. In studying the files of the Campbell Clinic, we have found that 713 of these fractures have been treated by members of the staff in patients 12 years of age or under. These do not include the fractures treated in the service of the John Gaston (City) Hospital. Fractures involving the elbow joint in children will be discussed in the order of their frequency: supracondylar fractures, condylar fractures, fractures of the neck of the radius, Monteggia fractures, fractures of the olecranon and T-condylar fractures of the lower end of the humerus (table

Impairment of circulation is indicated mainly by swelling, cyanosis and paresthesia or anesthesia of the hand and fingers.

Absence of the radial pulse before reduction is usually caused by pressure on the brachial artery at the site of fracture, but it may indicate trauma to the brachial artery which has resulted in thrombosis or severance of this vessel. If the radial pulse is absent owing to pressure on the brachial artery, the pulse will usually return during reduction of the fracture. If the radial pulse is present before but absent after the arm is placed in acute flexion, the amount of flexion is too great, and the elbow should be extended sufficiently to restore adequate circulation.

Examination for damage to nerves should be carried out before and after manipulation of the fracture. This is easily done, for the median, ulnar and radial nerves have functions which are readily determined. With paralysis of the median nerve the patient is unable to appose the tip of the thumb to the small finger. Paralysis of the ulnar nerve prevents "fanning" of the fingers and abduction of the small finger. With involvement of the radial nerve the patient is unable to dorsiflex the wrist or to extend the metacarpophalangeal joints. The sensory distribution in the hand of the median, ulnar and radial nerves is well known and can easily be tested. Embarrassment to the surgeon is prevented by discovering any existing injury to the nerves before rather than after the manipulation.

Volkman's contracture is an extremely serious complication, which may follow any fracture about the elbow but which is most commonly seen after supracondylar fractures. This condition may be unavoidable and has been reported secondary to severe swelling of the soft tissues in patients who were not treated with casts, bandages or any other type of appliance. Volkman's contracture can usually be prevented by careful observation of the circulation at regular intervals and prompt release of any constricting appliance when impairment of circulation is present.

TABLE 1.—Types of Fractures

	No. of Cases	Percentage
supracondylar fractures.....	465	65.4
condylar fractures.....	180	25.3
fractures of the neck of the radius...	34	4.7
Monteggia fractures.....	16	2.2
olecranon fractures.....	12	1.6
condylar fractures.....	6	0.8
Total.....	713	100.0

Supracondylar fractures are undoubtedly more common than these data indicate, as most of them are treated by the patient's home physician, while a large portion of the more complicated fractures, especially those requiring surgical treatment, are referred.

Damage to the nerves and blood vessels, which frequently accompanies fractures about the elbow, is often of more consequence than the fracture itself. For this reason, whether or not the nerve and the blood supply to the forearm are intact should be ascertained before reduction and observed at regular intervals during treatment.

From the Willis C. Campbell Clinic.

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## SUPRACONDYLAR FRACTURES

The most common fracture about the elbow joint in children is a supracondylar fracture. The youngest patient with a supracondylar fracture in this series was 14 months of age. These fractures have occurred in all age groups up to the 12 year limit, which was set arbitrarily for this study. Table 2 indicates the incidence according to age of supracondylar fractures, condylar fractures and fractures of the neck of the radius. This table indicates that supracondylar fractures occur most frequently between the ages of 5 and 8.

A supracondylar fracture can usually be diagnosed clinically. The diagnosis should always be confirmed by roentgenographic examination, in order to determine the exact type of fracture. This is necessary to differentiate a supracondylar fracture from a condylar fracture, as the proper

TABLE 2.—Age Incidence of Supracondylar Fractures, Condylar Fractures and Fractures of the Neck of the Radius

Age in Years	Supracondylar Fractures (465), Percentage	Condylar Fractures (180), Percentage	Fractures of the Radial Neck (34), Percentage
1.....	1.37	0.66	....
2.....	3.21	1.32	3.45
3.....	6.20	3.30	3.45
4.....	10.10	7.24	....
5.....	16.15	15.12	6.90
6.....	14.22	11.82	6.90
7.....	11.45	13.81	3.45
8.....	14.22	8.56	10.35
9.....	10.10	11.83	10.35
10.....	4.35	9.87	24.11
11.....	5.05	9.87	13.80
12.....	4.58	6.60	17.34
	100.00	100.00	100.00

treatment of these two types of fracture is entirely different. The presence or absence of the radial pulse should be ascertained and the condition of the circulation in the hand evaluated. A careful examination should be made for damage to nerves. When impairment is present, the radial and the median nerve are most often involved. The radial nerve was involved in 2.4 per cent of the supracondylar fractures of this series and the median nerve in 1.5 per cent. The ulnar nerve was involved in 2 fractures. In 1 of these there was a combined lesion of the radial and the ulnar nerve. The neural lesion was temporary in all but 2 patients, who had involvement of the radial nerve. At operation the radial nerve was found to be severed, and it was sutured. One of these patients obtained a good result, and we were unable to trace the other. The median nerve passes in front of the lower end of the humerus between the condyles, while the radial nerve passes anterior to the lateral condyle. Either may be damaged by forward

displacement of the proximal fragment. The ulnar nerve may be involved, as reported by Siris.<sup>1</sup>

In some supracondylar fractures the swelling of the soft tissue is too extensive to permit immediate manipulation. In such circumstances it is necessary to treat the patient with some form of traction, such as has been described by Dunlop and Hart,<sup>2</sup> or to place the extremity in a posterior splint until the swelling subsides sufficiently to permit manipulation. If reduction is postponed because of swelling, any pressure on the brachial artery should be relieved before the posterior splint is applied. This usually requires partial reduction of the fracture, as the swelling tends to persist and subsides slowly when wide separation of the fragments is present.

In the vast majority of cases, especially when the patient is seen within a few hours after the fracture, immediate manipulation can and should be done. We have found that, in general, the simplest and most satisfactory method of treatment is manipulation and immobilization by strapping with adhesive tape with the elbow in flexion (Jones position). The reduction is accomplished by traction on the forearm and flexion of the elbow. At the same time that this manipulation is being carried out, the distal fragment is forced forward with the thumb while posterior pressure is applied on the shaft of the humerus with the fingers of the same hand. Lateral or medial displacement of the distal fragment is usually corrected by traction on the forearm. Occasionally it is necessary to align the distal fragment with the proximal fragment by pressure on the medial or lateral condyle. This is easily accomplished while traction is being applied to the forearm. It is difficult to correct lateral or medial displacement after the elbow is flexed. Unless the brachial artery has been thrombosed or severed, the radial pulse should be palpable after the manipulation. The forearm should not be flexed to or beyond the point of obliteration of the radial pulse. It is unwise and usually not necessary to flex the elbow beyond 45 degrees. The palm of the hand should face the sternoclavicular joint, with the humerus in slight internal rotation. The forearm should not be flexed so that it is parallel with the arm. When the former position is used the carrying angle will be preserved after extension of the elbow, while in

1. Siris, I. E.: Supracondylar Fracture of the Humerus: Analysis of 330 Cases, *Surg., Gynec. & Obst.* 68:201 (Feb.) 1939.

2. Dunlop, J.: Transcondylar Fractures of the Humerus in Childhood, *J. Bone & Joint Surg.* 21:17 (Jan.) 1939. Hart, V. L.: Reduction of Supracondylar Fracture in Children, *Surgery* 11:23 (Jan.) 1942.

the latter position the carrying angle may be lost when the elbow is extended.

When the adhesive dressing is applied with the elbow in the flexed position, care should be taken to pad the antecubital fossa and to fill the space between the forearm and the arm with cotton. Otherwise excoriation of the skin may occur. The adhesive tape strapping should cover the entire arm and forearm from the axilla to the wrist, including the elbow. This prevents "window edema" about the elbow or between the strips of adhesive tape. It is well to wrap the wrist and hand with a gauze bandage, as this minimizes the amount of swelling in the hand (fig. 1). After this form of treatment, one can not be too careful in checking the circulation. It should be checked at least twice a day for the first three days. It is our practice to hospitalize patients with this type of fracture for twenty-four hours, so that their reaction to the anesthetic and the circulation of the extremity can be watched under optimal circumstances. If excessive swell-

ing occurs, the patient is hospitalized for a longer period. The relatives should be instructed that if signs of impaired circulation are noted in the hand and the patient should return to the doctor immediately. With this type of dressing, the adhesive tape can easily be cut and the elbow allowed to extend sufficiently to reestablish adequate circulation. As the swelling subsides, the flexion of the elbow can be gradually increased and the reduction maintained by reinforcing the strapping.

After reduction, a roentgenogram should be made to determine whether or not the reduction is satisfactory. A second roentgenogram should be taken in one week to ten days following the reduction to ascertain if any change in position of the fragments has occurred. If the fragments have slipped sufficiently to warrant remanipulation, this should be done immediately, as union occurs rapidly in children (fig. 2). The average time necessary to maintain the fixation with ad-

hesive tape strapping is three to four weeks, at the end of which time there is usually sufficient callus to allow removal of the adhesive tape and application of a posterior splint or sling. At the end of four or five weeks, gradual active and passive motion of the elbow can be resumed. Extension of the joint should be increased slowly. It may take three to six months, and in rare cases even a longer period to obtain full extension of the elbow. Full motion of the elbow in children can usually be obtained by active motion associated with use. Physical therapy is rarely necessary for a child. Full motion might be obtained quicker by the use of physical therapy, but the time element is of no economic importance to a child. Gradually increasing active motion is safer and much cheaper than passive motion and massage carried out by a physical therapist. The custom of carrying weights to promote extension is not advised. The biceps and brachialis muscles contract to support the weight, thus preventing extension. If the weight



Fig. 1.—A, the elbow has been placed in acute flexion, slightly in excess of the usual amount. B, the space between the forearm and the arm has been filled with cotton and the entire area covered with adhesive tape, to prevent edema. C, the adhesive dressing has been covered with a gauze bandage; also the hand and the wrist have been covered, to prevent edema of the hand. The upper extremity is supported by a sling, which is fenestrated at the elbow and the wrist.

ing occurs, the patient is hospitalized for a longer period. The relatives should be instructed that if signs of impaired circulation are noted in the hand and the patient should return to the doctor immediately. With this type of dressing, the adhesive tape can easily be cut and the elbow allowed to extend sufficiently to reestablish adequate circulation. As the swelling subsides, the flexion of the elbow can be gradually increased and the reduction maintained by reinforcing the strapping.

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could be applied constantly over a long period, it would overcome the muscular spasm and be of value. The child usually rests the biceps and brachialis muscles before the muscular spasm is overcome by fatigue. When the elbow is actively extended, the triceps muscle contracts at a time when the flexor muscles of the elbow are physiologically relaxed, thus facilitating extension of the joint.

Occasionally satisfactory reduction of a supracondylar fracture by manipulation is impossible. This is particularly true for patients with an oblique fracture in the supracondylar region, as seen in the anteroposterior roentgenogram. The oblique fracture line, ending in a thin pointed spicule of bone, forms an inclined plane, on which it is extremely difficult to engage and stabilize the fragments by manipulation alone, as there is a constant tendency for the distal fragment to slip out of position. Flexion of the elbow may increase the displacement rather than

stabilize the fragments, as is done when the fracture is transverse in the anteroposterior view. If satisfactory reduction cannot be obtained by manipulation, an open operation with internal fixation is indicated (fig. 3). In this series, 11.8 per cent of the 465 supracondylar

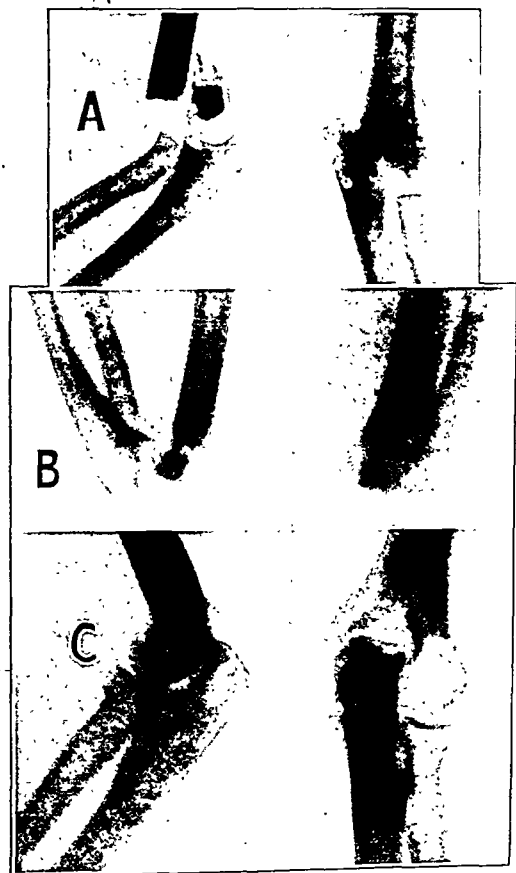


Fig. 2.—*A*, typical supracondylar fracture in a child aged 6. *B*, appearance of the fracture after closed reduction and immobilization, with the elbow in flexion. *C*, the same patient sixteen years after the fracture. Function and external contour of the elbow are normal.

fractures required open reduction. This percentage is higher than one would expect in unselected cases, as most of the patients were referred to the clinic after failure to secure satisfactory position of the fracture by manipulation. Forty-three per cent of the fractures requiring open reduction exhibited callus with early malunion, which prevented further manipulation. Fifty-seven per cent of those requiring open reduction were fresh fractures in which satisfactory position could not be maintained by closed manipulation.

**Technic for Open Reduction.**—The fracture is exposed through short longitudinal incisions over the medial and lateral aspects of the elbow,

which expose the epicondyles and the medial and lateral borders of the humerus along the intermuscular septums. The incisions should be of appropriate length to expose the condyles of the humerus and the site of fracture. Care should be taken not to injure the ulnar nerve as it passes behind the medial condyle. With these exposures the fracture can be accurately reduced and held in position by placing a rustless steel nail through each condyle and into the shaft of the humerus (fig. 3). When the wounds are closed the ends of the nails should be covered with skin and subcutaneous tissue, but they should be allowed to protrude from the bone enough to be palpated easily beneath the skin. With this procedure the nails can usually be removed with the patient under local anesthesia.

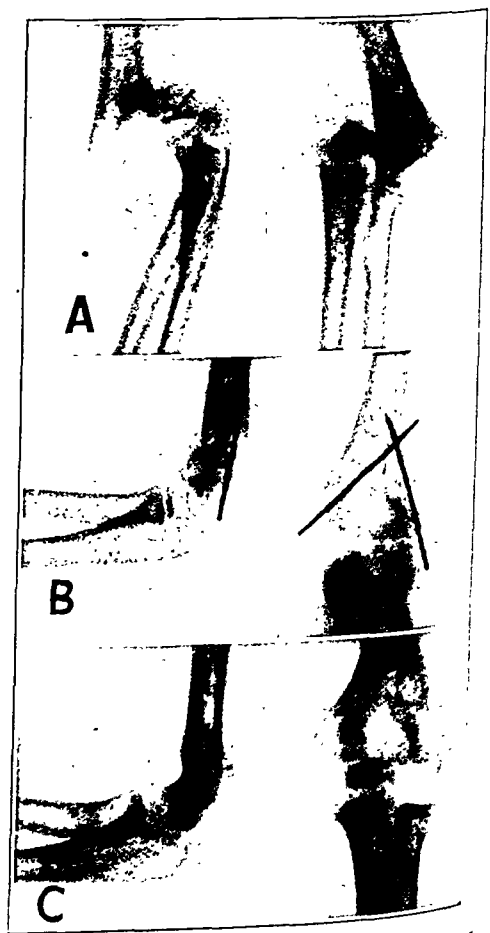


Fig. 3.—*A*, supracondylar fracture in a child aged 5 years, in whom closed reduction was not satisfactory. *B*, position of fragments following open reduction and internal fixation with stainless steel nails. *C*, appearance of bones four years after operation. The nails were removed one month following operation. End result: normal flexion and extension of the elbow and pronation and supination of the forearm.

Union is nearly always sufficiently solid to permit removal of the nails in six to eight weeks.

Supracondylar fractures in children are nearly always of the "extension" variety, i. e. the fracture occurs with the elbow in extension. The force is transmitted through the hand and forearm to the elbow. The supracondylar fracture results from hyperextension of the elbow. The distal fragment is forced posteriorly, and the proximal fragment protrudes anteriorly. The fracture line, as viewed in the lateral projection, may be either transverse or oblique (from posterosuperior to anteroinferior), usually the latter. Rarely (less than one-half of 1 per cent in this series) a supracondylar fracture may be of the "flexion type," which results from direct force applied to the elbow with the joint in flexion. In this event, the distal fragment is displaced anteriorly. The "flexion type" of fracture cannot be treated by flexing the forearm on the arm (Jones position), as flexion increases the

TABLE 3.—*Fractures of the Humeral Condyles*

	No. of Cases	Percentage
Lateral condyle.....	124	68.8
Medial epicondyle.....	23	12.3
Medial condyle.....	23	12.9
Total.....	180	100.0

displacement of the fragments. This fracture is best treated with the elbow in extension or, if necessary, by open reduction.

Four per cent of the supracondylar fractures in this series were compound. For this type of fracture, in addition to the treatment of the fracture, adequate care of the compound wound is necessary.

#### FRACTURES OF THE HUMERAL CONDYLES

Fractures of the humeral condyles (180 cases) represent 25.3 per cent of the fractures of this series. Of the fractures of the humeral condyles, fracture of the external condyle is the most frequent, as demonstrated in table 3. The carrying angle predisposes to a valgus strain when force is transmitted to the condyles through the extended forearm. This probably accounts for the preponderance of fractures of the lateral condyle.

The symptoms and physical findings with condylar fracture may be similar to those of a supracondylar fracture; however, the treatment is entirely different. The differential diagnosis should be made by roentgenographic examination. Condylar fractures of the humerus with

displacement in children require open operation and internal fixation in order to obtain a satisfactory end result. Occasionally a condylar fracture without displacement occurs which does not require open reduction, but if there is displacement of a condylar fracture open reduction is indicated. The extensor muscles of the forearm have a common origin from the lateral condyle, and the flexor muscles have a common origin from the medial condyle. The muscular pull on a condylar fracture will usually redisplace the fragment, even if successful manipulation of the fragment into position can be accomplished (fig. 4). Accurate reduction of a condylar fracture by manipulation is practically impossible, as the surgeon is unable to grasp and control the small fragment. Condylar fractures, especially those of the lateral condyle, usually show marked displacement with rotation, which may be of any amount up to 180 degrees. At operation the fragments always appear larger than the roentgenogram would lead one to expect, as the condyles in children are partially formed by cartilage, owing to lack of complete ossification. The younger the child the larger the actual size of the fragment as compared with its apparent size in the roentgenogram.

Experience has taught us that if these fractures are not accurately reduced and the reduction maintained, either malunion or nonunion of the condyle will result. With either complication there is a disturbance in growth, as these fractures pass through the centers of growth and the epiphysial lines of the lower end of the humerus. If a patient has a lateral condylar fracture which has not been properly treated, as a rule the medial condyle continues to grow while the growth of the lateral condyle is retarded, with a resultant gradually increasing cubitus valgus (increase in the carrying angle). This condition produces a progressive increase in tension on the ulnar nerve, and it is common to see a delayed palsy of the ulnar nerve in patients with this complication during adult life (fig. 5). If nonunion or malunion occurs in the medial condyle, the lateral condyle will usually grow faster than the medial condyle, with a resultant gradually increasing cubitus varus, or a loss in the carrying angle. With either cubitus valgus or cubitus varus, traumatic arthrosis is apt to occur in the elbow during adult life, owing to the irregular surface of the joint, which results from malunion or nonunion (figs. 4, 5 and 6). These complications can be prevented by an accurate early open reduction and internal fixation of the fracture (fig. 7). The operation of choice consists of a lateral longitudinal incision or a medial longitudinal incision which

exposes the involved condyle. When the site of fracture has been adequately exposed, the condyle should be anatomically reduced as one portion of a jigsaw puzzle is fitted into another. This reduction should be held by a nail or screw of either rustless steel or vitallium. Satisfactory position of the condyle cannot usually be maintained by sutures. It is difficult to suture a fractured condyle into position accurately, as there is not sufficient soft tissue to hold the sutures. If the sutures are passed through the bone the bone tends to cut surgical gut (catgut) or silk sutures, while wire sutures tend to cut through the soft bone forming the condyle. After the open reduction and the internal fixation, the

standpoint, we have found that the fixation does not prevent normal growth of the humerus when it is removed as recorded here (fig. 7). In the patients that have had early accurate reduction of the condylar fracture with internal fixation, normal growth of the lower end of the humerus has continued. The patients with malunion or nonunion have shown pronounced disturbances in growth (figs. 4, 5 and 6). A condylar fracture should be operated on within the first few days of the fracture. If open reduction is not possible, fibrous tissue fills the space between the condyle and the humerus. Under these circumstances, accurate reduction of the condylar frag-

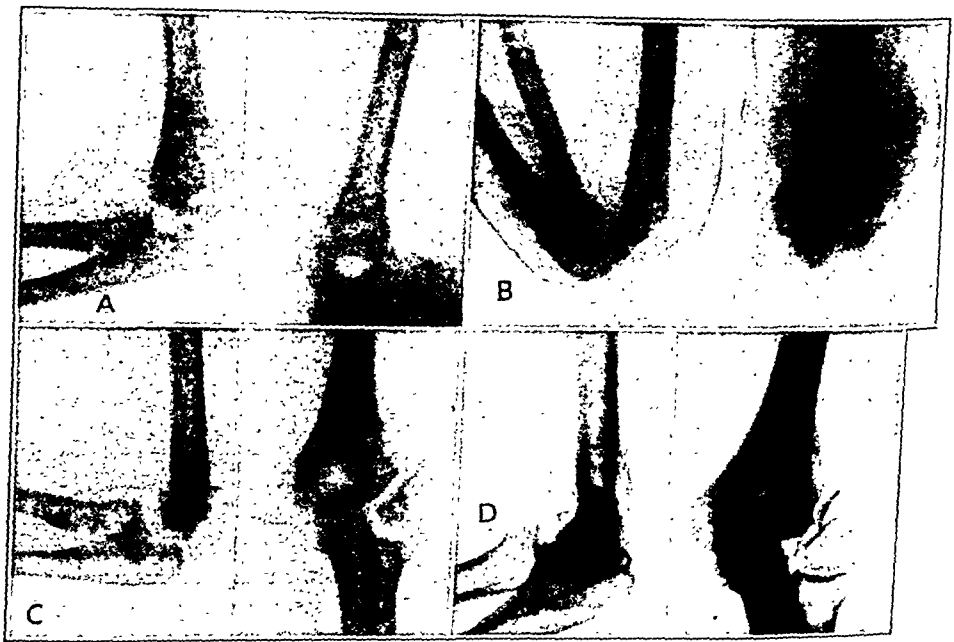


Fig. 4.—A, fracture of the lateral condyle of the humerus with moderate displacement in a child aged 7. B, position of fragments following closed reduction. This is apparently a satisfactory reduction. C, definite union of the fracture of the lateral condyle ten months following reduction, illustrating that open reduction and internal fixation should have been employed. D, appearance of the fracture twelve years after reduction. This patient has a moderate increase in the carrying angle. There is crepitation on flexion and extension of the elbow. Pain is experienced with changes in weather. The patient was 19 years of age at the time of this report. As the patient grows older the pain and roughening in the elbow joint will probably increase.

arm is immobilized, with the elbow at 90 degrees or slightly flexed beyond the right angle. Union is usually sufficiently solid to permit gradually increasing active and passive motion of the elbow in approximately four weeks following the operation. It has been our practice to remove the internal fixation in six to eight weeks after the operation. This can often be done with local anesthesia.

There are theoretic disadvantages in passing a nail or screw through the growing area and the epiphyseal line of the condyle. From a practical

standpoint, we have found that the fixation does not prevent normal growth of the humerus when it is removed as recorded here (fig. 7). If definite malunion or nonunion is allowed to develop, the position of the condylar fragment may be improved by an operation; but the chance of securing an excellent anatomic result with continued normal growth in the lower end of the humerus has been lost. Disturbances in growth in the lower end of the humerus have developed in the patients in whom open reduction has been postponed four or more weeks following a condylar fracture. The necessity for early open reduction and internal fixation

f condylar fractures was emphasized by Speed and Macey in 1933.<sup>3</sup>

#### FRACTURES OF THE MEDIAL EPICONDYLE

The medial epicondyle is fractured more often than the lateral condyle but less frequently than the lateral condyle. Usually there is an epiphyseal separation of the medial epicondyle; occasionally the fracture line may pass through osseous tissue. Displacement of the epicondylar fragment may vary from a negligible amount to an actual displacement of the fragment into the elbow joint. In the latter event, there is usually

an associated lateral subluxation of the elbow joint. Trauma to the ulnar nerve may be the result of pressure by the epicondylar fragment or, in cases of subluxation of the elbow, secondary to avulsion of the nerve from the ulnar groove. In the majority of cases there is definite displacement of the medial epicondyle. This displacement is maintained by the pull of the flexor muscles of the forearm through their common origin from the medial epicondyle



Fig. 5.—Old nonunion of a lateral condylar fracture in a patient aged 39, resulting from an injury at 9 years of age. Note nonunion of the lateral condyle, with pronounced irregularity of the elbow joint. The carrying angle is definitely increased. Symptoms referable to the ulnar nerve were first noted twenty-five years after the fracture, and there was complete paralysis of the ulnar nerve (both motor and sensory, including atrophy of intrinsic muscles of the hand) five years later, when the patient was first seen. This unfortunate result would have been avoided by open reduction and internal fixation at the time of the original fracture.

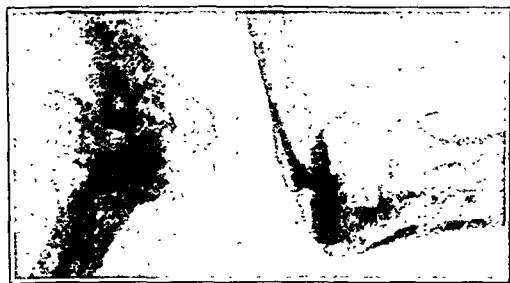


Fig. 6.—Old nonunion of a fracture of the lateral condyle in a patient 28 years of age, resulting from an injury at the age of 3. There is a distinct increase in the carrying angle, with delayed ulnar palsy. The lesion of the ulnar nerve improved after transplantation of the nerve at the elbow.

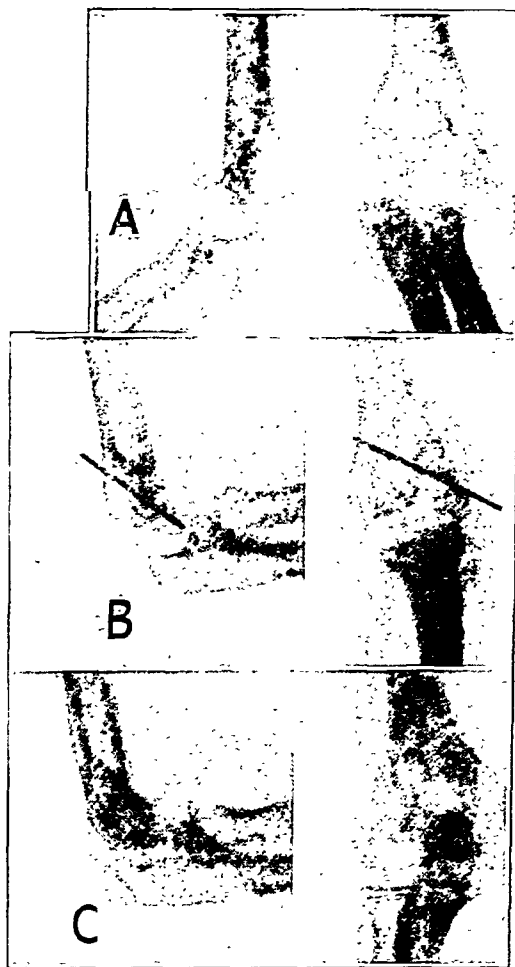


Fig. 7.—*A*, typical fracture of the lateral condyle of the humerus with rotation in a child aged 7 years. *B*, roentgenogram taken during operation, illustrating reduction of the fracture and internal fixation with a stainless steel nail. *C*, result four years after operation, showing bony union and no disturbance in growth of the lower end of the humerus. The patient had normal flexion and extension and normal pronation and supination. The external contour of the elbow and the carrying angle were normal.

Open reduction and internal fixation of the displaced epicondyle are necessary if normal development and growth in the region of the medial epicondyle are to be assured. When the epicondyle is displaced into the joint, open reduction is

3. Speed, J. S., and Macey, H. B.: Fractures of the Humeral Condyles in Children, *J. Bone & Joint Surg.* 15:903 (Oct.) 1933.



necessary to remove the fragment from the joint and to reduce the subluxation. If this is not done, traumatic arthrosis of the elbow joint will develop, owing to the loose fragment in the joint and the subluxation of the elbow. In patients with moderate displacement of the epicondylar fracture, nonunion will develop if open reduction, with accurate reposition of the fragment, and internal fixation are not employed. In these patients a malformation of the internal epicondylar region will develop with growth, but this will not cause an increase or a decrease in the carrying angle, as the epiphysis of the internal epicondyle does not enter into the formation of the elbow joint proper. Traumatic neuritis may develop in the ulnar nerve as a result of nonunion of the medial epicondyle.

In the average case, the best treatment for a fracture of the medial epicondyle is open reduction, anatomic reposition of the fragment and maintenance of this position with a small rustless steel nail. This internal fixation should be removed in four to six weeks. If the end of the nail is allowed to protrude from the bone so that it is easily palpable beneath the skin, its removal can be accomplished without difficulty, with local anesthesia.

#### FRACTURES OF THE NECK OF THE RADIUS

Fracture of the neck of the radius (34 cases) represents 4.7 per cent of the fractures of this series. The head of the radius is rarely fractured in a child (2 of the 34 cases). The neck of the radius is usually fractured just distal to the epiphysal line of the head, and the head of the radius is most often displaced laterally and anteriorly or laterally and posteriorly. The displacement may vary from a slight amount of impaction to a complete separation of the head from the shaft. The head is usually angulated in proportion to its displacement. The angulation may be 90 degrees in patients with complete separation of the radial head.

It is difficult to change the position of the head of the radius by manipulation. If the displacement of the head of the radius is slight, no treatment other than the application of a posterior elbow splint is necessary. This splint should be used for approximately three to four weeks, after which time gradually increasing active and passive motion in the elbow may be instituted. If there is appreciable displacement of the head of the radius, open reduction is indicated (fig. 8). Removal of the head of the radius is usually the treatment of choice for an adult, but removal of the head of the radius is contraindicated for a child and should not be done. If the head of

the radius of a growing child is removed, cubi valgus will gradually occur as the forearm grows.

In the cases in which an operation is indicated the head of the radius is exposed and the fracture reduced. The reduction may be maintained without internal fixation by slight impaction of the fracture line. In some cases internal fixation is necessary; small bone pegs, metallic nails

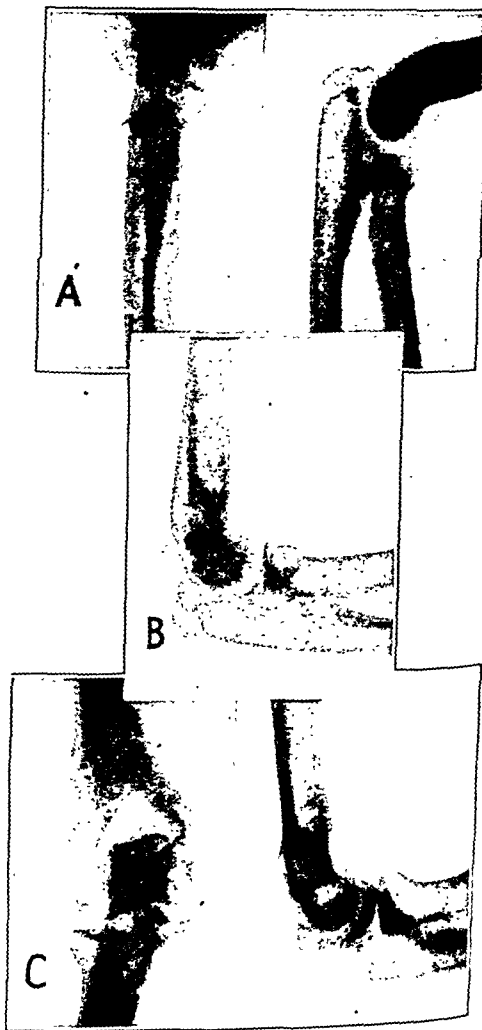


Fig. 8.—A, typical fracture of the neck of the radius with angulation in a child aged 10 years. B, position of the head of the radius following open reduction and insertion of a homogenous bone peg. C, result four years following operation. The function of the elbow was normal at this time. The homogenous bone peg has disappeared, and there is normal development of the head of the radius.

and silk sutures have been used for the fractures in this series. When metallic nails are used they should be removed in five to six weeks.

With the average fracture of the neck of the radius in a child, displacement is not sufficient to warrant an operation. When operation is not

warranted the end result is usually excellent. When the displacement is sufficient to warrant operation, normal function of the elbow usually results. Occasionally there may be some limitation of motion in the elbow joint, especially in pronation and supination; but as a whole the end results have been satisfactory.

#### MONTEGGIA FRACTURES

Fracture of the ulna with dislocation of the head of the radius (Monteggia fracture) occurred in 2.2 per cent (16 cases) of the fractures of this series. It is important in this condition not to overlook the dislocation of the head of the radius. It should be borne in mind that if there is a fracture of the ulna with overriding or distinct angulation without fracture of the radius, in all probability the head of the radius has been dislocated, as it is mechanically impossible to have any material shortening of the ulna associated with a fracture without either a fracture of the radius or a dislocation of the head of the radius. Accordingly, in all cases of fracture of the ulna a careful clinical and roentgenographic examination of the elbow joint should be made to determine whether or not the head of the radius is dislocated. For adults, the preferred treatment of fracture of the ulna with dislocation of the head of the radius is open reduction (Speed and Boyd<sup>4</sup>), as angulation of the ulnar fracture toward the radius invariably occurs owing to the pull of the supinator muscle on the proximal fragment. Unless internal fixation is applied to prevent this angulation, some permanent limitation of pronation and supination is the rule. In children the ulna angulates toward the radius, the same as it does in adults, but the major portion of this angulation may be corrected by growth (fig. 9). This is particularly true for young children, as the amount of correction that can be expected is directly proportionate to the subsequent growth. The important factor for a child is an accurate reduction of the dislocation of the head of the radius and maintenance of this reduction. This can usually be obtained by manual reduction of the dislocated head followed by immobilization of the forearm in a position halfway between full flexion and 90 degrees of extension. Usually the fracture of the ulna will be sufficiently united at the end of six weeks to allow gradual extension of the elbow. If the head of the radius redislocates after exten-

sion of the elbow, an operation should be done and a fascial loop placed about the neck of the radius to prevent further redislocation. In a fresh fracture, if the head of the radius cannot be successfully reduced by closed manipulation, an open reduction of the dislocation of the head of the radius with substitution of the annular

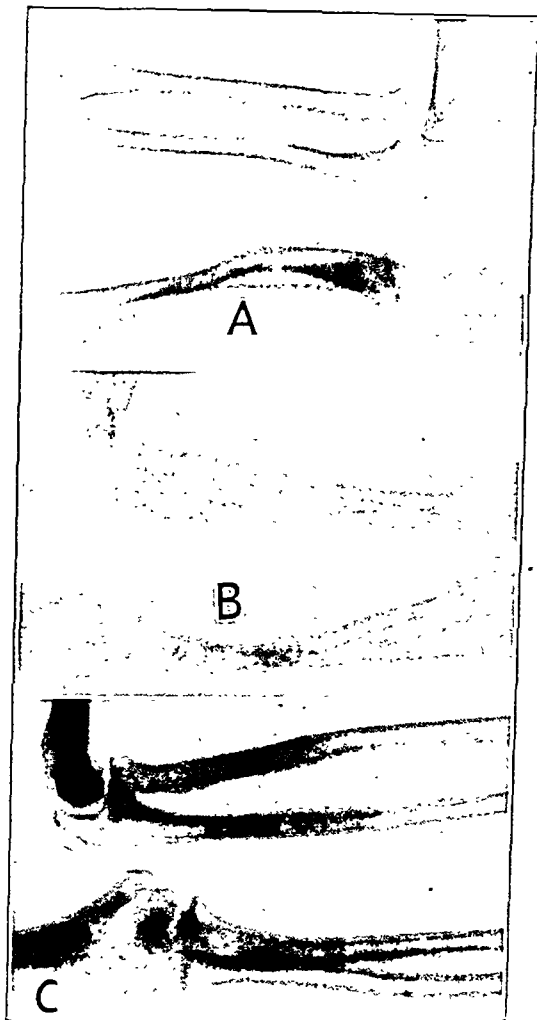


Fig. 9.—A, fracture of the ulna with dislocation of the head of the radius in a child aged  $2\frac{1}{2}$ . B, roentgenogram taken three weeks following closed reduction. The head of the radius is in its normal position, but the ulna has united with definite angulation at the site of fracture. C, result twelve years following the fracture. The angulation of the ulna has been nearly corrected by growth, and the patient has normal contour and function of the elbow, including pronation and supination. In older children this amount of ulnar deviation would not be corrected by growth.

ligament by a fascial loop or suturing of the torn annular ligament should be carried out in a child as in an adult. If open reduction is necessary to reduce the dislocation of the head of the radius, internal fixation should usually be applied to the fracture of the ulna at the same time.

4. Speed, J. S., and Boyd, H. B.: Treatment of Fractures of the Ulna with Dislocation of the Head of the Radius (Monteggia Fracture), *J. A. M. A.* **115**: 1699 (Nov. 16) 1940.

## FRACTURES OF THE OLECRANON

Fracture of the olecranon in children is relatively rare (12 cases, or 1.6 per cent of the fractures in this series). Occasionally a fracture occurs through the epiphysis of the olecranon and does not require any treatment other than immobilization in a splint. A fracture of the olecranon may occur without material displacement, in which case it can also be treated by immobilization in a splint. If wide displacement of the fragments occurs, open reduction with wiring or some other form of internal fixation should be carried out in a child as in an adult.

## COMMINUTED FRACTURES OF THE LOWER END OF THE HUMERUS

Comminuted fracture of the lower end of the humerus (T-condylar fracture) is the least common fracture involving the elbow joint in children (6 cases, or 0.8 per cent of the fractures in this series). These fractures require open reduction and internal fixation to reconstruct the articular surface of the lower end of the humerus. We have employed the same operative principles for children with this condition as for adults. The fragments are most readily assembled and the internal fixation applied through a posterior incision similar to that used by Campbell<sup>5</sup> for arthroplasty and described by Speed<sup>6</sup> for old posterior dislocation of the elbow. This technic has been well described and illustrated by Van Gorder.<sup>7</sup>

## CONCLUSIONS

Supracondylar fractures are by far the most common fractures about the elbow joint in children. They can usually be treated by manipulation. Special care should be taken to prevent Volkmann's contracture following these fractures.

Fractures of the humeral condyles are relatively common in children, and an accurate differential diagnosis between this lesion and a supracondylar fracture should be made by roentgenographic examination. Condylar fractures should be treated by immediate open reduction and internal fixation, to prevent subsequent deformity and traumatic arthrosis of the elbow joint. These complications are seen in adult

life, as a result of disturbance in growth following an ununited or malunited condylar fracture.

Fractures of the neck of the radius occur in children should be treated by conservative operative means, depending on the amount of displacement present. The head and neck of the radius should not be removed in a growing child.

With fractures of the ulna, careful clinical roentgenographic examination of the elbow should be carried out to determine whether or not a dislocation of the head of the radius is present, and if present adequate treatment should be instituted.

Fractures of the olecranon are rare in children; when they occur with displacement, open reduction and internal fixation are usually indicated.

Comminuted fractures of the lower end of the humerus require open reduction and internal fixation to restore the anatomic alignment of the articular surface of the lower end of the humerus.

## ABSTRACT OF DISCUSSION

DR. JOHN DUNLOP, Pasadena, Calif.: I shall confine my remarks to two types of fracture: (1) separation of the median epicondyle of the humerus and its complications; (2) transcondylar fracture of the humerus. In the first type, the mechanism of the fracture should be known to fully understand its many ramifications. For instance, a stress is placed on the median epicondyle while it is still a separate epiphysis, not having developed sufficiently to have become joined firmly to the shaft of the humerus. When this force is sufficient owing to the pull of the flexor muscles of the forearm the medial epicondyle breaks away at the epiphysal line and with the contraction of this muscle group it is drawn distally, and there is an accompanying tear of all the soft supporting tissues of the medial side of the elbow. With the loss of these supporting tissues, the elbow joint opens on the medial side, much as a book is opened. When this happens, the median epicondyle may fall into the elbow joint and it may become caught there. If now the surgeon attempts to reduce what he judges to be a dislocation or a partially reduced dislocation, he may grind this mass (the median epicondyle) into the surface structures of the condyle of the humerus or into the olecranon process, causing irreparable damage. If the force which separates the medial side of the joint is sufficient and the lateral structures of the elbow joint hold, a fracture of the head of the radius may occur. Also the lateral condyle of the humerus may become fractured from the same application of force, which may produce a fracture of the head of the radius. If the application of force continues it is possible for the soft supporting tissues on the lateral side of the joint to give way, with a complete lateral dislocation of the forearm on the humerus. This is depicted in my article "Elbow Injuries," *American Journal of Surgery*, February 1925. The repair of simple epicondylar separations is easy. The epicondyle with its muscular attachments should be found and fixed in position. The ulnar nerve should

5. Campbell, W. C.: Arthroplasty of the Elbow, *Ann. Surg.* 76:615 (Nov.) 1922.

6. Speed, J. S.: An Operation for Unreduced Posterior Dislocation of the Elbow, *South. M. J.* 18:193 (March) 1925.

7. Van Gorder, G. W.: Surgical Approach in Supracondylar "T" Fractures of the Humerus Requiring Open Reduction, *J. Bone & Joint Surg.* 22:278 (April) 1940.

always be located and retracted during this operation. Temporary metal fixation has been found satisfactory. Fractures of the head of the radius or lateral condyle must of course be cared for if present.

Of even more interest to me are transcondylar fractures, fractures of the lower end of the humeral metaphysis which pass through the olecranon fossa. I first treated such fractures by lateral traction in 1927, because I had found that reduction was difficult by manipulation and even more difficult to hold after reduction. Reduction must be maintained in order to preserve the olecranon fossa, for if this space becomes filled by bony tissue or bony repair tissue, full extension or even full flexion may be impossible, owing to a bony block.

By traction reduction may be obtained, and if the traction is maintained until there is sufficient callus a functioning elbow joint will almost certainly result. Open reduction of this fracture should be condemned as an absolutely unnecessary procedure if the traction method of reduction is understood. The great majority of permanently flexed elbows are due to poor results from this fracture, and in my experience this method of handling them has been highly satisfactory. I have never seen a permanently flexed elbow following this method of treatment. The diagnosis of a transcondylar fracture can always be made from the roentgenogram by the fish tail appearance of the distal end of the proximal fragment, and when this is seen the fracture immediately calls for this type of treatment. It has been suggested that traction for reduction prevents Volkmann's ischemic paralysis. Traction should be applied immediately on the appearance of the first symptoms of impaired circulation.

DR. J. WARREN WHITE, Greenville, S. C.: My remarks are going to be applied particularly to supracondylar fractures. I think, however, that an unnecessarily fine distinction is made between the supracondylar and the transcondylar type. It is true that with transcondylar fractures gross deformities are more likely to develop later. Either I have been lucky or there have not been many cases in which late deformities have occurred. Late deformities of the elbow in my part of the country are not common, although I do see more fractures of an elbow than any other injury of bone. As the men in western South Carolina seem to be afraid of fractures of the elbow, I treat many of them as well as fractured femurs, but not so many of the other types of fracture.

I should like to describe one device for immobilizing elbows, which I have been using for many years and which holds the elbow in acute flexion satisfactorily, allowing me to keep watch of the elbow and the circulation in the hand efficiently. This is a simple, standard angular sling. The elbow is in acute flexion. The agonist of the sling goes around the hand, one corner comes under the axilla of the affected arm and the other comes up over the shoulder of the other arm. They are pinned together, not tied, usually with a supplementary neck pad, for comfort. The right angle corner below the affected elbow comes up under the arm, and four thicknesses of the sling are pinned together: two tails, the diagonal and the corner. One pin holds practically the whole arrangement, but other pins

at strategic points are desirable. In the first week after reduction, in addition I put a 2 inch (5 cm.) strip of adhesive tape around the whole sling and around the body, including of course the upper part of the affected arm. It can be lowered or raised and it is a good deal more easily adjusted than the adhesive tape to which Dr. Boyd referred. Of course it is far easier to take off. The arrangement can be easily adjusted every day, cleansing is facilitated, and the patient can be kept comfortable. The use of the sling facilitates the taking of roentgenograms—another advantage of this simple dressing. Frequently when lateral roentgenograms are being taken the arm is rotated out so that a deformity is produced, which is not there if the elbow has not been strained. I am sure that many have noted that particular point.

I have not had the difficulty Dr. Dunlop has mentioned, and I do not know when I have done an open reduction. This sling is most useful for caring for these frequent injuries.

DR. WALTER BLOUNT, Milwaukee: I cannot emphasize too frequently that fractures in children are different. I am gratified to note that Dr. Boyd's paper and the discussion have backed up this contention. I have developed another maxim which is particularly applicable to fractures of the elbow: "The hard ones look easy, and the easy ones look hard." As an example, the supracondylar fracture, which often fills the practitioner with terror, is relatively easy to treat by the methods just outlined. Fracture of the lateral condyle, on the other hand, is frequently missed and called a sprain because of the minimal deformity, when treatment by open reduction is really indicated.

I should like to emphasize two points particularly. The first concerns the accuracy of reduction that is necessary. At the elbow, as elsewhere in children, alinement is of great importance, apposition of less. Proper alinement includes correction of rotational and angular deformities. Dr. Dunlop's method accomplishes this well. At the Milwaukee Children's Hospital it is used routinely when a patient comes in nine or ten hours after the fracture with a large amount of swelling. After the swelling has been reduced, the elbow is frequently manipulated under anesthesia in the interest of obtaining more perfect position.

I should like to endorse the use of Dr. Dunlop's method of traction in cases of threatened Volkmann's ischemic contracture. It may well be combined with hot compresses, with relief of the symptoms in most cases. Operation should, of course, be carried out if the symptoms are not relieved.

In 1 case an ordinary transcondylar fracture was reduced by manipulation with the elbow under anesthesia. Perfect position was obtained. Symptoms of ischemia appeared, and the arm was kept in lateral traction for three weeks before the threat to the circulation disappeared. By this time, union had occurred, with rather distinct posterior displacement of the distal fragment but normal alinement. The distal end of the proximal fragment protruded as a block to flexion. Judgment to leave the fracture in this position was vindicated by the appearance of the fracture seven months later and again two years after the injury. At the latter date, motions of the elbow were normal and symmetric with the other side. The protruding angular fragment of bone had completely disappeared.

## ARCHIVES OF SURGERY

early, a bony block in the olecranon fossa will wear with time. I do not share Dr. Dunlop's opinion over this temporary complication. Errors in treatment of rotation or angulation are usually permanent.

Dr. Boyd did not have time during his presentation to emphasize a fundamental rule, "Never take out the distal head of a child." The fracture usually occurs through the neck rather than the head of the bone. There is only slight displacement, the deformity can be left as it is. If the displacement is severe, open reduction will probably be necessary. The fragments can be brought into good position and maintained by acute flexion of the elbow. Internal fixation is not necessary. The important thing is not to remove the head as one would for an adult. Fractures in children are different.

DR. HAROLD B. BOYD, Memphis, Tenn. (closing): The excellent discussion of this paper is appreciated, and I wish to thank the discussers.

Dr. Dunlop has emphasized the importance of transcondylar fractures. In my series the majority of patients with transverse transcondylar fractures were treated successfully in the Jones position. Oblique transcondylar fractures were difficult to reduce and accounted for most of the open reductions.

Dr. White has described an interesting type of dressing for supracondylar fractures.

Dr. Blount has emphasized the importance of not removing the head of the radius in a child. He also stated that accurate anatomic reduction is not as necessary for children as for adults. This is true when the fracture involves the shaft of the humerus, but this principle does not hold for fractures of the humeral condyles, as those fractures must be accurately reduced to prevent disturbances in growth and the resulting deformity.

# EFFECT OF TOPICAL APPLICATION OF VITAMINS AND SOME OTHER CHEMICALS ON THE HEALING OF WOUNDS

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BOSTON

Many studies have been reported of the effect of various substances in promoting the healing of wounds. Most of these investigations have dealt with antibacterial drugs, but some have dealt with dietary measures which tend to improve the condition of the subject as a whole and in turn increase the rate of healing of wounds.<sup>1</sup> Deficiency in the body of proteins,<sup>2</sup> vitamins A and D<sup>1a</sup> and vitamins C<sup>3</sup> impairs the rate of healing of wounds.

A number of local factors influence healing. Messer and McClellan<sup>4</sup> found that wounds benefited more from an alkaline  $p_H$  than from an acid one. Several investigators<sup>5</sup> reported that the local application of concentrated urea is of distinct aid in promoting healing of wounds, particularly for removing debris and necrotic tissues. However, this therapy is often associated with marked discomfort. Compounds containing the sulfhydryl radical<sup>6</sup> stimulate growth of tissue, but their application has frequently been associated with pain and a disagreeable odor.

From the Thorndike Memorial Laboratory, Second and Fourth Medical Services (Harvard), Boston City Hospital, and the Department of Medicine, Harvard Medical School.

1. (a) Holmes, A. H.: Wound Healing, *New England J. Med.* **227**:909-921, 1942. (b) Arey, L. B.: Wound Healing, *Physiol. Rev.* **16**:327-406, 1936.

2. Thompson, W. D.; Ravdin, I. S., and Frank, I.: Effect of Hypoproteinemia on Wound Disruption, *Arch. Surg.* **36**:500-508 (March) 1938. Whipple, A.: The Critical Latent or Lag Period in the Healing of Wounds, *Ann. Surg.* **112**:481-488, 1940.

3. Holman, E.: Vitamin and Protein Factors in Pre-Operative and Postoperative Care of the Surgical Patient, *Surg., Gynec. & Obst.* **70**:261-269, 1940. Langan, T. H., and Ingalls, T. H.: Vitamin C Deficiency and Wound Healing: An Experimental and Clinical Study, *Ann. Surg.* **105**:616-625, 1937. Hunt, A. H.: The Role of Vitamin C in Wound Healing, *Brit. J. Surg.* **28**:436-461, 1941. Lund, C. C., and Crandon, J.: Ascorbic Acid and Human Wound Healing, *Ann. Surg.* **114**:776-790, 1941.

4. Messer, F. C., and McClellan, R. H.: Surgical Agglots: A Study of Their Function in Wound Healing, *J. Lab. & Clin. Med.* **20**:1219-1226, 1935.

5. Robinson, W.: Use of Urea to Stimulate Healing of Chronic Purulent Wounds, *Am. J. Surg.* **33**:192-197, 1936. Holder, H. G., and MacKay, E. M.: The Use of Urea in the Treatment of Infected Wounds, *J. A. M. A.* **108**:1167-1169 (April 3) 1937.

There have been many observations<sup>1a</sup> of the effects on the healing of wounds of the local application of vitamin A, vitamin D and cod liver oil. In general, these substances have been found to stimulate granulation and epithelization.

In view of the general growth-promoting properties of the vitamins we have studied the effects of essentially all of these substances when applied directly to wounds. In this investigation we were interested in increasing the rate of healing in normal rats. The animals used were of the Wistar strain. They had been fed fox chow, carrots and celery leaves for several weeks before the beginning of the experiment. The majority had also been given cod liver oil and brewers' yeast occasionally, but they received neither of these substances for about one month before the study was started.

## METHODS OF STUDY

The experiments were conducted with four groups of rats. There were some differences in the conditions of the experiments for each group.

**EXPERIMENT 1.**—There were 45 male rats in this group, most of which weighed from 250 to 300 Gm. The hair over the dorsal portion of the chest was shaved and the skin scrubbed with 70 per cent alcohol. While the animal was under ether anesthesia a scalpel was used to produce three lesions in the dorsal paravertebral region of each rat. On the left side an elliptical area of skin, 1.3 by 0.5 cm., was excised, the incision extending into but not through the corium. About 2 cm. away from this lesion another one of about equal size, but extending into the subcutaneous layer, was produced. On the right side, in an area about 1.3 cm. square, essentially all of the tissue outside of the thoracic cage was excised. Of the 45 animals so prepared, 6 received no treatment, while the remaining 39 were divided into groups of 3 and were treated with one of the following substances:<sup>7</sup> vitamin A,

6. Reimann, S. P., and Hammett, F. S.: Cell Proliferation Response to Sulfhydryl in Man, *Proc. Soc. Exper. Biol. & Med.* **27**:20-22, 1929. Riley, J. F.: Sulfhydryl Compounds and Wound Repair, *Brit. M. J.* **2**:516-519, 1940.

7. The preparation of vitamin A, supplied by Winthrop Chemical Company, New York, contained 65,000 U. S. P. units of natural vitamin A per gram. The vitamin E was also supplied by Winthrop Chemical Company, in spherical capsules with a volume of ap-

(Footnote continued on next page)

thiamine hydrochloride, nicotinic acid, riboflavin, calcium pantothenate, pyridoxine, biotin, vitamin C, vitamin D, crude liver extract, a vitamin mixture or sesame oil. All of the water-soluble vitamins used were suspended in sesame oil, to delay the absorption of these substances and thereby prolong their exposure to the margins of the wounds. About 8 cc. of sesame oil was placed in a series of sterile glass vials. To each, one of the following substances was added: 100 mg. of thiamine hydrochloride, 100 mg. of pyridoxine, 30 mg. of the methyl ester of biotin, 100 mg. of calcium pantothenate, 100 mg. of vitamin C, 20 mg. of riboflavin, 100 mg. of nicotinic acid or 100 mg. of liver extract. Each of the fat-soluble vitamins was mixed with an equal volume of sesame oil. The vials were shaken well, and a small amount of solution was taken from each one and mixed together to form what we called the "vitamin mixture." Two drops of one solution was placed on each wound and gently massaged. Sterile rubberized silk, which had been sewed to a gauze bandage, was placed directly in contact with the wound. One end of the bandage was anchored to the skin at a point distant from the wound. The animals treated with liver extract, pyridoxine and the "vitamin mixture" were caged singly to avoid the ingestion of the applied material by another rat. The remainder of the animals were caged in groups of 3, according to the type of treatment. A new supply of vitamins was applied daily, at which time the degree of healing of the wounds was carefully noted. A biopsy of the superficial lesion was made after four days, of the deeper lesion after twelve days and of the deepest lesion after sixteen days. Sections were made uniformly through the center of the lesion. The tissues were fixed in Zenker's solution and stained with eosin and methylthionine chloride (methylene blue). The sections were studied particularly from the point of view of extent of epithelialization, mitosis, thickness of fibrous layer, vascularization, evidence of necrosis and evidence of infection. However, none of the substances exerted a beneficial effect.

**EXPERIMENT 2.**—A somewhat similar experiment was conducted with another group of rats. There were 48 female rats in the group, and they were essentially the same size as the animals in experiment 1. From each dorsal paravertebral region of these animals was excised an area of tissue about 1.3 cm. square, including all of the structures external to the thoracic cage. Six of the animals remained untreated, but the remaining 42 were divided into groups of 3 and were treated with each of the substances<sup>8</sup> used in experiment 1 and also

proximately 0.2 cc., each containing 50 mg. of mixed tocopherols equivalent to 30 mg. of alpha tocopherol. The vitamin D (crystalline vitamin D<sub>2</sub>) was supplied by Winthrop Chemical Company, in capsules slightly larger than those containing vitamin E; each capsule contained 50,000 U. S. P. units of vitamin D<sub>2</sub> in sesame oil. The riboflavin was furnished in crystalline form by Winthrop Chemical Company. The thiamine hydrochloride, calcium pantothenate, vitamin C and nicotinic acid were supplied in crystalline form by Merck & Co., Inc., Rahway, N. J. The methyl ester of crystalline biotin was furnished by the S. M. A. Corporation, Chagrin Falls, Ohio. The liver extract was Wilson's crude product no. 343.

8. The biotin used in this experiment was biotin concentrate (no. 5,009). It contained 200 gammas of biotin per 1 cc. and was supplied by the S. M. A. Corporation.

with cod liver oil. Each animal treated with the latter was kept in a separate cage. Two drops of each solution was applied daily to each wound. No bandages were used in this group. Four days after the wounds were produced we began injecting 0.05 cc. of a set of solutions which were of the same concentration as the ones applied topically. The injections were made in the subcutaneous tissue just beneath each of two edges of the wound. The lesion on the left side was totally excised for study after ten days of treatment, and the one on the right was excised after seventeen days. The sections were prepared and studied in the manner outlined in experiment 1. There was no evidence that any of the substances had exerted an advantageous effect on the healing process. However, at the sites of the injections sterile abscesses had formed. We believed that these reactions could be attributed to sesame oil but we investigated them further, as well as the effects of several other oils and gums, in the hopes of obtaining a vehicle which would delay the absorption of the vitamins but would not cause an inflammatory reaction.

**EXPERIMENT 3.**—The solutions tested were peanut oil, olive oil, cotton seed oil, liquid petrolatum, sesame oil, oleic acid, glycerin, hydrosorb<sup>9</sup> and two preparations of acacia. The hydrosorb was prepared as a thin paste with water. The two preparations of acacia were prepared as 5 per cent aqueous solutions. All solutions were sterilized. Daily injections of 0.1 and 1 cc. were made into the subcutaneous tissues of rats with an attempt to observe sterile technic. Each substance was injected at six sites, and biopsies of these sites were made after two, four and six days respectively. The tissue was fixed in Zenker's solution and the sections were stained with eosin and methylthionine chloride (methylene blue). An inflammatory reaction was observed in each of the biopsy specimens. An acute necrotic reaction with the formation of sterile abscesses was observed in the wounds treated with hydrosorb, oleic acid and one preparation of acacia. A moderate inflammatory reaction occurred at the sites of injections of peanut oil, liquid petrolatum and the other preparations of acacia. The reactions to cotton seed oil, sesame oil, olive oil and glycerin were relatively mild. However, even with these there were cystic changes, with the formation of thin fibrous walls and a surrounding area of lymphocytes, macrophages, plasma cells and a few polymorphonuclear cells.

**EXPERIMENT 4.**—In view of the reactions to oils and gums, we undertook another experiment in which we avoided the use of sesame oil as a vehicle. Furthermore, in this experiment we attempted to make all the wounds of exactly the same size by using a hypodermic punch. With this process practically no bleeding resulted, and the wounds appeared clean. In this experiment the water soluble vitamins were used in essentially the same dilution as in experiments 1 and 2, but water was used as the diluent instead of sesame oil. The fat-soluble vitamins were not diluted. This experiment also differed from the others in that no cod liver oil or liver extract or "vitamin mixture" was used but a

9. One acacia solution and the hydrosorb were supplied by Abbott Laboratories, North Chicago. Hydrosorb is said to be a water-absorbent ointment base consisting of a mixture of oleic acid ester and polyethylene glycol, diethanolamine, oleic acid and white petrolatum. The other acacia was in a white granular form supplied by Arthur H. Thomas Co., Philadelphia.

additional substances were tried. Amino acids<sup>10</sup> and adenosine were used because of their ability to stimulate the growth of yeast.<sup>11</sup> The amino acids were not diluted, but the adenosine was used in quantities of 20 mg. per 10 cc. of water. We also tested the effect of hydrosulphosol, biodyne and urea and sulfathiazole ointment. Hydrosulphosol was diluted 1:4 with water, and the other two substances were used just as they were. There were 67 rats in this group. Most of them were males weighing about 300 Gm. After shaving the hair from the entire back, we placed three round holes 1.5 cm. in diameter through the skin on

treated with hydrosulphosol, 8 treated with biodyne and 3 treated with sulfamerazine alone. Nine animals had no treatment. One of the 3 animals in each group was treated with sulfamerazine as well as one of the other substances. With this arrangement we could evaluate the effect of the vitamins or the other substances when they were associated with the local or general effects of sulfamerazine and could compare these changes with the ones occurring in the total absence of this drug.

The  $pH$  of the chemicals was determined before and after they were applied to some of the wounds (table 1). The  $pH$  of the wound after application of the various substances ranged from 6.1 to 8.2.

After the wounds had become 3 days old daily injections of 0.025 cc. of the test substance were made subcutaneously at the rostral and caudal margins.

The general appearance of the wounds was observed carefully each day. On the sixth day measurements were made of the diameter of the lesions. Although the lesions treated with calcium pantothenate were slightly narrower than the others, there was no remarkable difference.

After therapy had been administered for ten days the animals were killed, and the most caudal lesion on the left side of each rat was excised and fixed in Zenker's solution for the preparation of microscopic sections. The other 5 wounds were excised in such a manner that the lateral and the medial margins of the lesions were barely eliminated. The tensile strength of the wound was then tested by clamping a hemostat to each end of the skin; one hemostat was suspended from a fixed hook, and the other was attached to a graduated container. Water was then poured into the container until the wound broke. There was no striking difference in the tensile strength of the various lesions. The ones treated with nicotinic acid and thiamine hydrochloride were slightly stronger than the remainder.

The microscopic sections were studied in the manner described in experiment 1. None of the substances used exerted a definite healing effect. In fact, several substances apparently retarded healing.

#### SUMMARY

A study was made of the effects of many substances on the acceleration of the healing of wounds when applied topically to uniform-sized wounds in normal rats. The substances studied were vitamins A, C, D and E, thiamine hydrochloride, nicotinic acid, riboflavin, calcium pantothenate, pyridoxine, biotin, hydrosulphosol, biodyne, urea-sulfathiazole ointment, amino acids, adenosine, liver extract, cod liver oil, a "vitamin mixture" and sesame oil. The effect of sulfamerazine used in conjunction with most of these substances was also observed. No definite benefit was derived from the use of any of these substances, as judged by frequent observations of the wounds, their strength and the microscopic changes.

*The pH of Wounds After the Application of Various Chemicals*

Chemicals Used	pH of Chemicals	pH Three Min. After Application	
		Wound 1	Wound 2
Thiamine hydrochloride.	3.3	7.6	7.6
Nicotinic acid.....	3.5	7.2	7.4
Calcium pantothenate...	6.2	7.2	8.0
Pyridoxine.....	3.0	6.3	6.3
Biotin.....	6.3	6.5	6.7
Riboflavin.....	8.4	8.2	8.1
Vitamin C.....	6.5	7.2	7.3
Hydrosulphosol.....	9.5	7.9	8.1
Adenosine.....	6.5	7.9	8.0
Urea acid.....	3.5	6.1	6.3
Sulfamerazine.....	8.5	7.5	7.9
		7.6	7.8
Untreated.....	...	8.0	8.0
		7.9	7.9

each side of the vertebral column. No treatment was applied to any of the wounds on the right side. To the lesions on the left was applied one of the vitamins used in experiment 1 or 2 or hydrosulphosol, biodyne, urea and sulfathiazole ointment, amino acids, adenosine or sulfamerazine. These substances were applied to each of the three lesions on the left. At least 3 rats were treated with each chemical. There were 4 rats

10. The amino acids (parenamine) were supplied by Frederick Stearns & Company, Detroit. The sulfathiazole and urea ointment was supplied by the Winthrop Chemical Company; it contained 5 per cent sulfathiazole and 30 per cent urea in a fat-soluble base. The adenosine was furnished by Dr. Fritz Lippmann of the Harvard Medical School. The hydrosulphosol was supplied by the Cottie-Wilson Laboratories, Los Angeles. This solution is stated to contain a thiol linkage pentathionate (ion) in compounds of disulfides and thiosulfates in water. The biodyne ointment was furnished by Sperti, Incorporated, Cincinnati. This ointment is said to consist of live yeast cell extract (1 per cent), nonsaponifiable liver oil (3 per cent) and phenylmercuric nitrate 1:20,000 in a specifically adapted liquid petrolatum-petrolatum base. The sulfamerazine was in a 2 per cent solution in the form of its sodium salt.

11. Loofbourov, J. R.: Role of Adenine Nucleotides in Growth Factors in Increased Proliferation Following Damage to Cells, *Nature*, London **150**:349-350, 1942.



# TRIPHALANGEAL BIFID THUMB

## REPORT OF SIX CASES

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In a previous communication on a study of 6 cases of triphalangeal thumb, we<sup>1</sup> postulated that triphalangism of the thumb should be regarded as incomplete development of one of the phalanges of the bifid thumb. According to this theory, "the additional phalanx of the triphalangeal thumb is not a true middle phalanx similar to that of the lesser fingers, but a remnant of the base of one of the phalanges of a bifid thumb."

Six cases of triphalangeal thumb associated with bifid thumb in the same person were observed subsequent to our first communication<sup>1</sup> and furnish supporting evidence for this theory. Six additional cases, found in the course of examination of draftees at the New York Recruiting and Induction Station, are presented here.

### REPORT OF CASES

**CASE 1.**—A Negro truckman, aged 27 years and a native of Georgia, was a well built, normal person except for his thumbs. His history revealed that his mother had long "bent thumbs" like his, and a maternal male cousin also had one deformed thumb.

On examination, both thumbs (fig. 1 *A*) were found to be triphalangeal and unusually long, especially the left, the tip of which reached to the level of the proximal interphalangeal joint of the index finger.

From the history it was learned that the left thumb had originally been bifid. It had consisted of two fully developed members, of which the radial member had been slightly shorter than the ulnar and had been amputated when the draftee was 6 years of age. A postoperative scar was present at the site of amputation, over the radial aspect of the left first metacarpus, just distal to its head.

The right thumb was not bifid. The nail phalanx of the right thumb was deviated radialward, while the nail phalanx of the left thumb presented slight ulnarward deviation (fig. 1).

The metacarpal phalangeal joint could be palmarly flexed between 180 and 100 degrees in the right thumb and between 180 and 120 degrees in the left thumb.

The greatest range of motion was possible in the proximal interphalangeal joint, which could be moved from 180 to 80 degrees in the right thumb and from 190 to 75 degrees in the left thumb. The nail phalanx

had the least motion, being restricted to between and 175 degrees in the right thumb and between and 170 degrees in the left thumb.

A roentgenogram (fig. 1 *B*) showed that both had three phalanges. The proximal and the middle phalanx of each thumb presented nothing unusual in

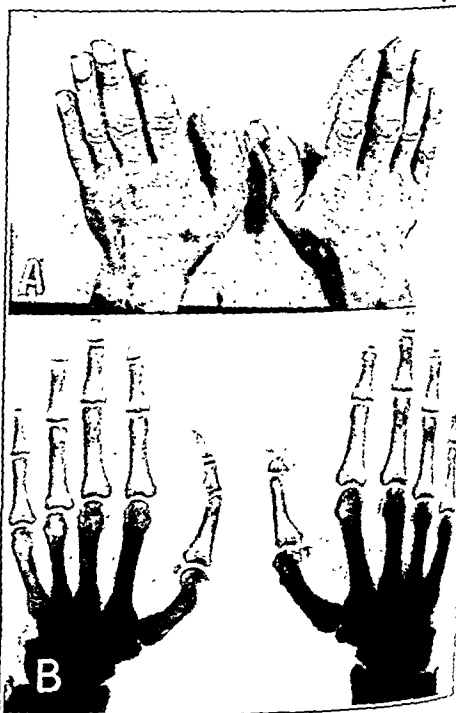


Fig. 1 (case 1).—*A*, photograph of both hands. Note the radial deviation of the nail phalanx of the right thumb and the ulnar deviation of the left thumb. A postoperative scar is visible at the base of the left thumb, resulting from amputation of the additional thumb. *B*, roentgenograms of both hands. Note the fully developed triphalangeal thumb on the left hand with a triangular middle phalanx of the right thumb. The punctate line over the right thumb shows the apparently missing part of the bifid nail phalanx.

1. Lapidus, P. W.; Guidotti, F. P., and Coletti, C. J.: Triphalangeal Thumb: Report of Six Cases, Surg., Gynec. & Obst. 77:178-186 (Aug.) 1943.

tant to mention also that the middle phalanx of the left thumb appeared somewhat trapezoid, a feature observed in many of the cases previously reported by us.<sup>1</sup>

The middle phalanx of the right thumb was small and wedge shaped, markedly resembling that in case 1 in our previous series.<sup>1</sup> The left first metacarpus was slightly shorter and somewhat stouter than the right. It had a larger head than the right, providing addi-

appeared to be free from abnormalities, although no roentgenogram was available.

**CASE 2.**—A Negro man aged 37 years was an accountant. His left thumb was triphalangeal; his right thumb was bifid distal to the metacarpal phalangeal joint and consisted of two similar radial and ulnar members, both triphalangeal and differing in that one was the mirror image of the other (fig. 2A).

On questioning, the draftee stated that his maternal uncle now deceased had had one bifid thumb. Another maternal uncle "had a straight right thumb without joints, which he was unable to bend." The draftee's mother was said to have both thumbs with the nail phalanx in radial deviation "exactly the same" as the draftee's left thumb. One of the draftee's brothers was reported to have an additional fifth finger, consisting of a small nail phalanx over the lateral aspect at the base of one of his fifth fingers; several cousins also were alleged to have this anomaly.

Examination of the hands revealed that the nail phalanges of the index, third and fourth finger of the left hand were amputated after an injury (fig. 2A). There was good motion of both thumbs, the right thumb (bifid) moving in toto.

The roentgenograms of the hands (fig. 2B and C) showed that the right first metacarpal bone was somewhat stouter than the left. Its head was V-shaped, articulating with the base of the two proximal phalanges of the bifid thumb. The adjacent surfaces of the bases of the proximal phalanges were fused together, forming a V-shaped common articular facet for the metacarpal head.

The ulnar member of the right thumb had a small wedge-shaped middle phalanx, which formed two distinct joints with the proximal and the nail phalanx respectively. The nail phalanx of the ulnar member of the right thumb was deviated radialward, pointing toward the radial thumb. The middle phalanx of the radial member of the right thumb was about the same size as the one on the ulnar side. It formed, however, only one distinct articulation with the head of the proximal phalanx (fig. 2B and 2C). The distal interphalangeal joint of the radial member of the right thumb apparently had failed to develop; it was represented by an hourglass constriction with a faint transverse line in the otherwise bony fusion of the middle and nail phalanges.

The left thumb was triphalangeal, with a practically normal-shaped nail and proximal phalanx. The small triangular middle phalanx (similar to that in case 1 in our previous series<sup>1</sup>) was interposed between the ulnar halves of the base of the nail phalanx and the head of the proximal phalanx. On the radial side, the head of the proximal phalanx and the base of the nail phalanx articulated directly with each other. The nail phalanx of the left thumb deviated radialward and had a small round hole at its distal end suggestive of the "duck bill" appearance described by Haas<sup>2</sup> (fig. 2C). Likewise, the nail phalanx of the ulnar member of the right thumb had a small round hole in its distal end, better seen in figure 2B.

Two sesamoids were present on the palmar aspect of the first metacarpal head of both hands. The second metacarpal head of both hands extended more distally than the third, the third finger, however, being longer than the second. No abnormalities were found over the carpal bones or at the joints of the wrists.

2. Haas, S. L.: Three-Phalangeal Thumbs, *Am. J. Roentgenol.* 42:677-682 (Nov.) 1939.

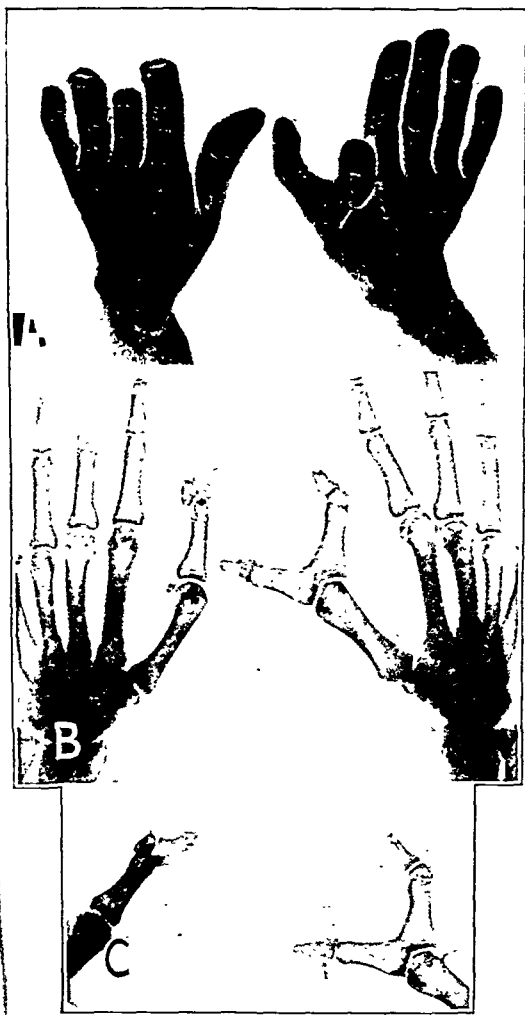


Fig. 2 (case 3).—A, photograph of both hands. Note the fully developed bifid right thumb and the usually long left thumb. B, roentgenograms of both hands, showing the bifid triphalangeal right thumb and the triphalangeal left thumb. The head of the second metacarpal extends farther distally than those of the others, especially on the right side. C, dorsopalmar view of both thumbs. Note the "duck bill" appearance of the nail phalanx of the left thumb, with a perforation at the distal end. The punctate outlines represent the missing parts of the bifid nail phalanges. Note that the middle phalanx of the radial member of the right thumb is partially fused to the nail phalanx, so that no distal joint is present (arrow).

nal articular surface for the basal phalanx of the amputated radial member of the originally bifid thumb. Except for this anomaly of the thumbs, the skeleton of the hands presented no peculiarities. The feet also

The feet were clinically normal. Roentgenograms of the feet presented no abnormalities except that there was a bifid right first tibial sesamoid, which possibly was an ununited fracture.

**CASE 3.**—A white truckman aged 18 presented a bifid right thumb with two separate nails (fig. 3A). The two right thumbs were fused except for a small distance over the distal half of the nail phalanx.

There was no known deformity in two generations.

The roentgenogram (fig. 3B) showed no abnormalities at the wrist or fingers except for the right thumb. The right first metacarpus was normal. The basal phalanx of the right thumb was somewhat thicker than the left and terminated in two round heads. The radial head articulated with a small middle phalanx, which in its turn articulated with the thin nail phalanx. The ulnar head of the basal phalanx articulated with a small wedge-shaped ossicle, which was interposed between it and the base of the nail pha-

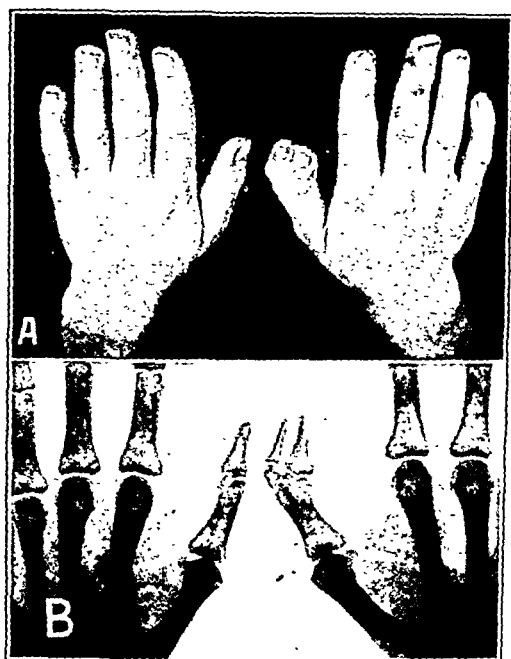


Fig. 3 (case 3).—A, photograph of both hands, showing the bifid right thumb. Note also the radial deviation of the nail phalanges of both fifth fingers (clinodactylism). B, roentgenogram of the thumbs. Note the bifid right thumb; the radial member is definitely triphalangeal, while the ulnar member has a small third phalanx interposed between the nail and the proximal phalanx only on the radial side.

lanx. The nail phalanx was normally shaped, and the ulnar part of its base articulated directly with the ulnar head of the basal phalanx. This also was an instance of a combination of bifid and triphalangeal thumb. Furthermore, the radial member of the bifid thumb had a fully formed middle phalanx, while the ulnar member had only a small wedge-shaped ossicle interposed only on the radial side between the basal phalanx and the nail phalanx. Thus the radial thumb resembled somewhat the thumbs in cases 2, 3 and 4 of our previous series<sup>1</sup>; the ulnar thumb was similar to that in case 1 of that series.

No roentgenogram of the feet was taken, but they appeared to be normal.

**CASE 4.**—A white clerk aged 18 years was not aware of any malformations in three generations of his family. His feet and left hand were normal.

The right thumb was bifid, with a normally shaped ulnar member and a small separate radial member. There was good mobility of the bifid right thumb. The draftee apparently used mainly the large ulnar member of the bifid thumb (fig. 4A).

Roentgenograms (fig. 4B) of both hands showed what appeared to be bony fusion between the greater and lesser multangular bones of both wrists.

The right thumb was bifid. The right first metacarpus was slightly shorter and thinner than the left. It continued distally into the normally shaped two phalanges of the ulnar thumb. An additional small

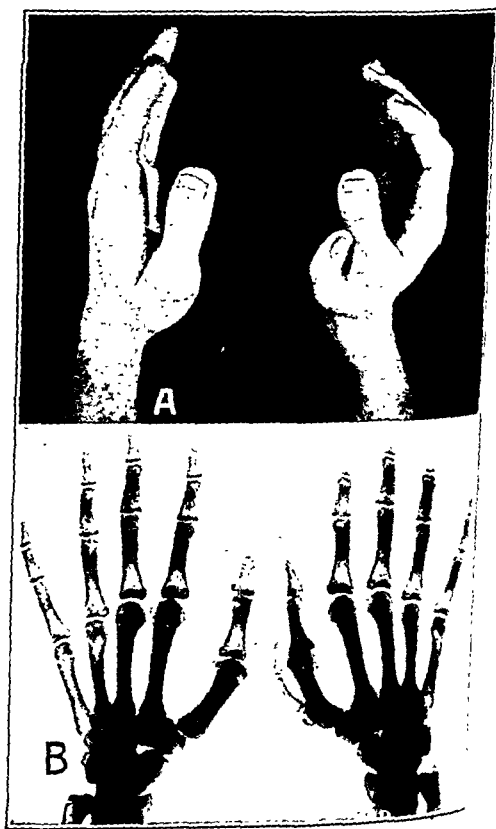


Fig. 4 (case 4).—A, photograph of both hands. B, roentgenogram of the hands. Note the bifid right thumb, the rudimentary radial member of which is triphalangeal.

triphalangeal thumb was attached by only soft tissue to the radial aspect of the base of the first metacarpus. This radial member consisted of a small round ossicle (apparently a basal phalanx), which did not form an definite articulation with the first metacarpus but articulated distally with a slender middle phalanx, which in turn articulated with a slender oblong nail phalanx.

**CASE 5.**—A white youth, aged 17 years, a hospital helper, had no history of a malformation in three generations of his family.

The draftee's fingers were normal. The thumbs were bifid and extra-

mately the same length as the fifth finger. The two members of the right thumb were completely separate distal to the metacarpal phalangeal joint. The left thumb had a cutaneous webbing connecting its two members and extending distally to the level of the proximal interphalangeal joint (figs. 5A and 5B).

The thumbs of both hands had normal range of motion, although the radial and the ulnar member of the bifid thumbs could be moved only together simulta-

developed, separate first metacarpal bones, with three phalanges for each member of the bifid thumb. The ulnar member of the thumb on each hand was somewhat larger and better developed, especially on the right side, than the radial member.

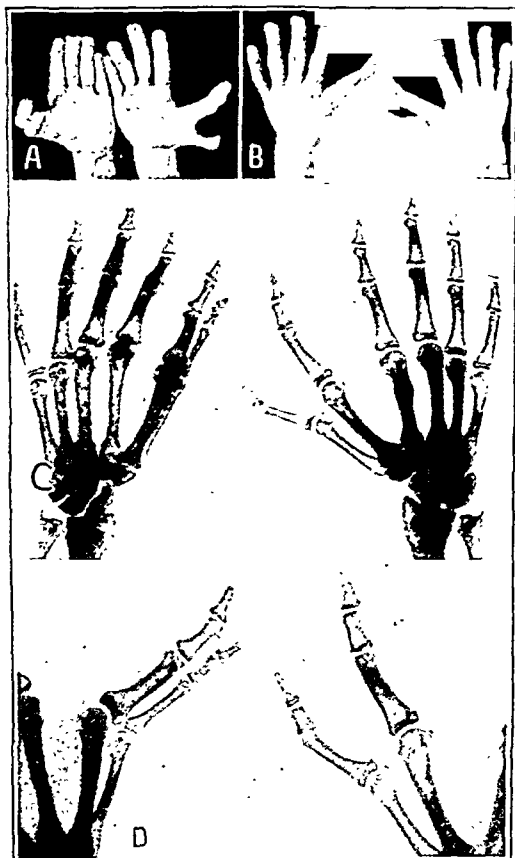


Fig. 5 (case 5).—A and B, photographs of both hands, showing the bilateral long bifid triphalangeal thumbs. Note the complete separation of the members of the right thumb, while the two members of the left thumb are connected with a soft tissue web, extending to the base of the nail phalanges. C, roentgenograms of both hands. Note the complete bifidism of the first rays, including the metacarpal bones. Both thumbs are triphalangeal. The left second metacarpal head extends farthest distally. The right second metacarpus originally apparently presented the same relation to the other metacarpal bones but became shortened by a fracture of its shaft. Note an additional ossicle (more visible on the right side) between the greater and lesser multangular bones articulating with the base of the first metacarpal of the ulnar thumb. D, dorsopalmar view of the thumbs, showing them in greater detail.

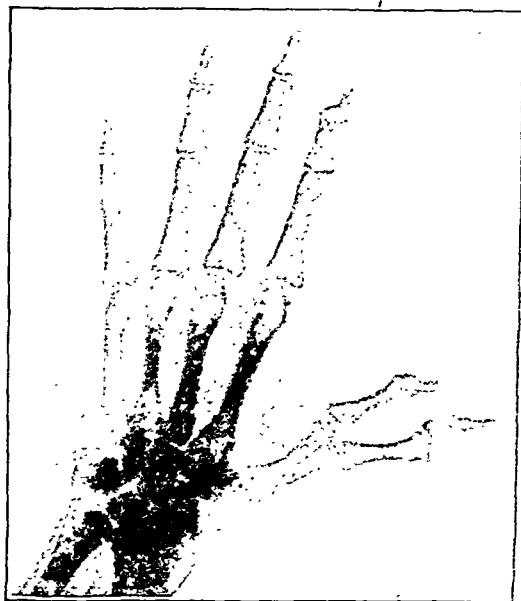


Fig. 6 (case 6).—Roentgenogram of the left hand, showing a trifold thumb, the radial member of which divides distally into two separate members, while the ulnar member has a normal appearance. Note that the middle thumb is triphalangeal with an underdeveloped distal interphalangeal joint. Note also the rather short, stout first metacarpal. The second metacarpal head extends farthest distally.

An additional small ossicle was present between the greater and the lesser multangular bone of each hand. This ossicle articulated with the base of the first metacarpal of the ulnar thumb.

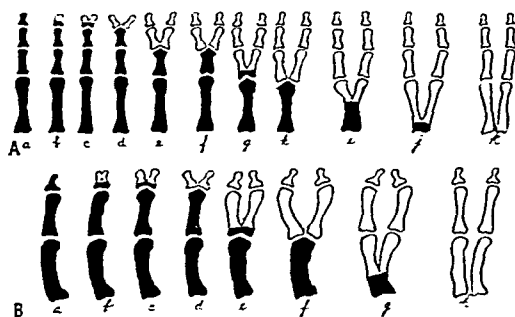


Fig. 7.—Schematic drawing illustrating: A, the various stages of longitudinal splitting, or bifidism, of the digital rays; B, the same stages as they occur in the first digit.

There was no other abnormality at the joints of the wrists. The right second metacarpal was somewhat deformed as the result of an old fracture.

CASE 6.—This subject<sup>3</sup> was also seen at the induction station, but no detailed history is available.

3. Courtesy of Dr. A. Sager.

ously, separate motion of either member being impossible.

Roentgenograms of the thumbs (figs. 5C and 5D) showed that both thumbs consisted of two fully developed rays. Each double thumb consisted of two fully

The draftee presented a left trifold thumb. As the roentgenogram shows (fig. 6), the first metacarpal was somewhat shorter and stouter than usual. Its broad head articulated with two entirely separate proximal phalanges. The ulnar member of the trifold thumb had a normally developed nail phalanx. The radial thumb was split distally again into two separate thumbs. The head of its proximal phalanx articulated with the nail phalanx on its radial side. On its ulnar side it articulated with a square middle phalanx, to which a nail phalanx was fused by bone. Thus the middle member of the trifold thumb apparently was also triphalangeal, but its distal interphalangeal joint failed to develop fully.

#### COMMENT

The 6 cases here reported illustrate the occurrence of a combination of triphalangeal thumb with bifid thumb in the same person with a

the fact that a bifid thumb was present is evident.

In case 2, there was a definite combination of bifidism with triphalangism of both the radial and the ulnar member of the bifid thumb. On the left side the thumb was not bifid but was triphalangeal, having a triangular middle phalanx. It is significant also that the middle phalanx of the left thumb and that of the ulnar member of the right thumb in this case presented the "duckbill" appearance (figs. 7 *A b* and 7 *B b*), which we interpreted as the most rudimentary stage of longitudinal splitting, or bifidism.

In case 3, bifidism and triphalangism occurred in the right thumb, the longitudinal splitting,

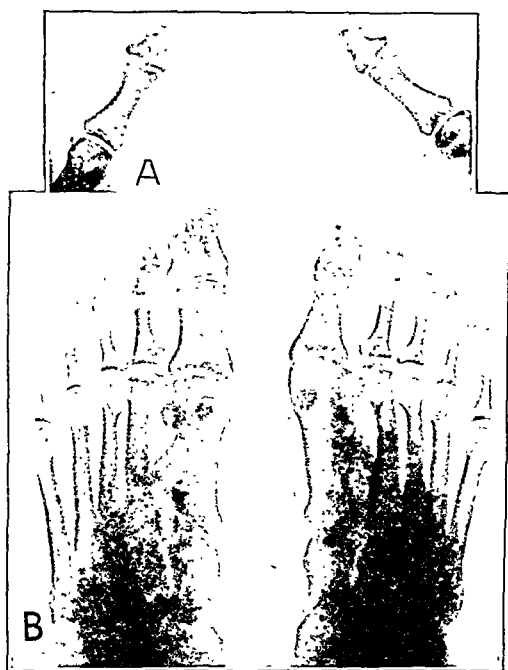


Fig. 8.—*A* and *B*, roentgenograms illustrating unusual widening of the distal phalanx of each thumb, especially the left. This should be interpreted as a tendency toward longitudinal splitting, especially since there is bifidism of the nail phalanx of the left hallux. Likewise, the nail phalanx of the right hallux also is unusually wide. The nails of both thumbs and of the right big toe were unusually large. The left big toe had a single wide nail with a longitudinal groove in the middle, also showing a tendency to longitudinal division.

trifold thumb in the sixth case. In 2 of the 6 cases there was a history of the presence of a similar deformity in the family.

In case 1, the remaining ulnar member of the bifid left thumb was triphalangeal. We have no way of knowing whether the amputated radial member also consisted of three phalanges, but



Fig. 9.—*A* and *B*, illustrations of the second stage (figs. 7 *Ab* and 7 *Bb*) ("duck bill" appearance). Note widening of the distal portion of the nail phalanx of the left hallux, with a small hole in its center (arrow). While the skeleton of the left big toe does not show any definite longitudinal splitting, the soft tissues, as shown in *B*, have undergone complete longitudinal splitting, so that the left big toe has two separate toe nails.

however, extending only through the middle and the nail phalanges of the thumbs. The basal phalanx of the right thumb presented only doubling of its head.

Case 4 illustrates bifidism of the right thumb with a fully developed biphalangeal ulnar member. The rudimentary radial member was triphalangeal and was attached to the ulnar thumb only by soft tissue.

Case 5 is most interesting because of the combination of three well developed phalanges of the thumbs with complete splitting of the first ray and doubling of the first metacarpal on both sides.

Case 6 illustrates the most unusual combination of trifold thumb with apparent triphalangism. A longitudinal splitting of the proximal phalanx of the thumb resulted in a bifid thumb. The radial member of the bifid thumb had in its turn also undergone a longitudinal splitting, extending

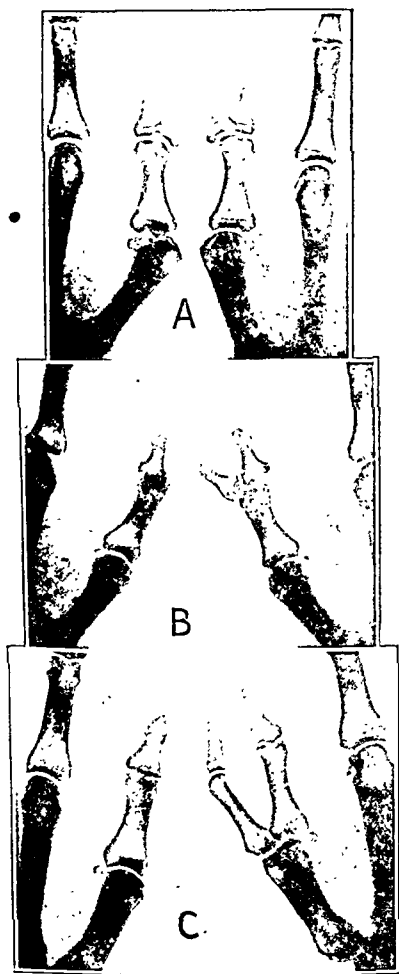


Fig. 10.—Roentgenograms illustrating gradually progressive longitudinal splitting of the thumb, corresponding to the stages illustrated in figures 7 Bc, d and f respectively.

only through its distal phalanx; thus there were one metacarpus, two proximal phalanges and three nail phalanges. The middle member of the trifold thumb presented evidence of triphalangism with an undeveloped distal interphalangeal joint; the radial and ulnar members on both sides of the triphalangeal thumb were biphalangeal.

A study of a large number of examples of polydactylism encountered among the draftees indicates that this anomaly and its various manifestations practically always conform to the following rule, as also observed by Mueller<sup>4</sup> and others: The supernumerary digits are the result of a more or less complete longitudinal splitting of the rays of the originally pentadactyl limb.

Figure 7 A schematically illustrates the various stages of this longitudinal splitting, or "bifidism," of the rays. It can be seen that this division starts distally in cases of mild deformity and extends proximally in cases of more pronounced deformity.

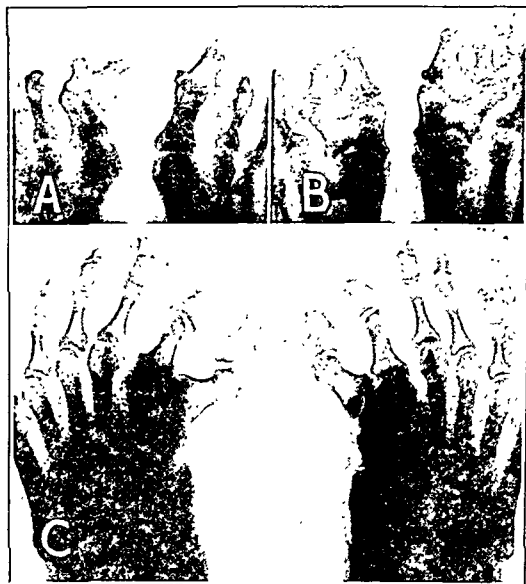


Fig. 11.—Roentgenograms illustrating different progressive stages of similar longitudinal splitting of the big toe. Note that in A the nail phalanx of the right big toe presents a "duck bill" appearance, corresponding to figures 7 Ab and 7 Bb, while the nail phalanx of the left big toe has undergone longitudinal splitting to a greater degree, corresponding to figures 7 Ac and 7 Bc. B corresponds to the stage illustrated in figures 7 Ae and 7 Be. C corresponds to the stage illustrated in figures 7 Ah and 7 Bf.

Figure 7 B illustrates the same process as it occurs in the first digit, which has only two phalanges.

As seen in figure 7 A, the bifidism may range from slight enlargement of the nail phalanx with a hole in its distal end (fig. 7 Ab and Bb) ("duck bill" appearance of Haas) to a complete duplication of the entire ray, including the metacarpal or the the metatarsal bones (fig. 7 Ak and Bh).

4. Mueller, W.: Die angeborenen Fehlbildungen der menschlichen Hand Erb- und Konstitutionsbiologie der Hand, Leipzig, Georg Thieme, 1937.

Various degrees of bifidism of the digital rays of the extremities have been encountered among the draftees. It is not within the scope of this paper to present all of the cases which would illustrate each of the stages of bifidism represented in figs. 7 *A* and 7 *B*. However, a few of the more striking examples are shown (figs. 8 through 12).

From the cases presented it is apparent that bifidism is not an infrequent occurrence and develops according to a definite pattern. The digital ray undergoes longitudinal splitting, which begins at the periphery and progresses proximally in cases of more advanced deformity. From the 6 cases presented here and the pre-

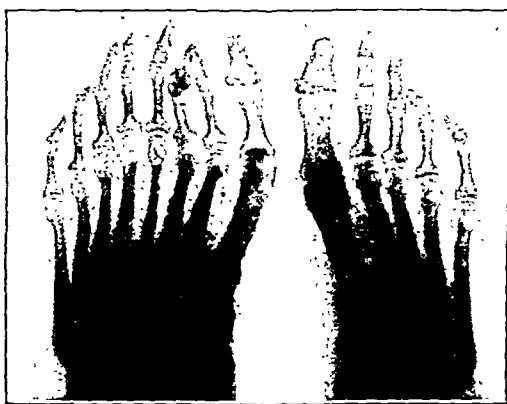


Fig. 12.—Roentgenogram of a normal right foot and a left foot in which there are a single first ray and a single fifth ray, but the second, third and fourth rays have undergone complete longitudinal splitting, including complete doubling of the respective metatarsal bones. Note that the two second toes are webbed together, while the other toes are completely separated.

viously reported 6 cases it is obvious that there is a close relationship between bifidism and triphalangism of the thumb.

Figure 13 illustrates graphically our theory concerning the development of triphalangism of the thumb. It may be assumed, as shown in this figure, that the phalanges of the originally bifid thumb (shown striated in the figures) failed to develop fully, while the bases of these phalanges (shown in solid black) still persist and simulate the third phalanx.

The evolution of triphalangism of the thumb probably follows most frequently the pattern

illustrated in fig. 13 *A*, since in most of the cases the deformity resembled morphologically the patterns illustrated in figures 13 *A a, b, c*, and *e*. In only 1 case (case 6, figure 12 in our previous article<sup>1</sup>) the pattern apparently followed the one illustrated in figure 13 *B b*. We have never observed the condition illustrated in figure 13 *B c* but may postulate its existence.

#### SUMMARY AND CONCLUSIONS

Five cases of triphalangism associated with bifidism of the thumb and 1 case of triphalangism combined with trifidism were studied. A history

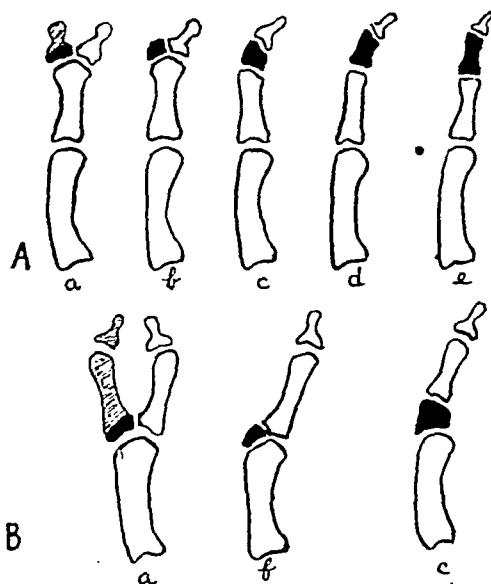


Fig. 13.—Drawing illustrating the development of triphalangism of the thumb.

of heredity of the anomaly was established in 2 of them.

Polydactylism must be regarded as a tendency toward longitudinal splitting of the originally pentadactyl limb. This splitting begins distally and extends proximally in cases of more advanced deformity.

The cases reported seem to substantiate the postulations set forth by us in a previous publication,<sup>1</sup> to the effect that the additional phalanx of a triphalangeal thumb is not a true phalanx similar to those in the lesser fingers but rather is a remnant of the base of one of the phalanges of a bifid thumb.

# VENOUS PRESSURE AS AN INDEX OF BLOOD FLOW IN THE UPPER EXTREMITY

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In 1909 Hewlett and Van Zwaluwenberg<sup>1</sup> described a method of determination of the rate of blood flow in the arm. The method consisted essentially in placing the upper extremity in a plethysmograph and measuring the initial increase in volume of the limb when the venous outflow was occluded by a pressure lower than the diastolic pressure. This principle has more recently been applied to more refined methods of determining the rate of blood flow in both upper and lower extremities.<sup>2</sup> Since vascular engorgement of an extremity is obvious when venous occlusion is produced, the idea suggested itself that measurement of the rate of rise in venous pressure in one of the large veins of the forearm might be to some degree indicative of the rate of blood flow in the extremity. If such a simple method can be developed from this preliminary study and by subsequent comparison with plethysmographic methods, the clinical estimation of peripheral blood flow in a variety of medical and surgical conditions may be greatly facilitated.

## METHODS AND RESULTS

Patients of various ages from surgical wards, either before operation or several days after operation, were used as subjects. They were covered with a single blanket and observed in a reclining position, usually one to three hours after the last meal. The experiments were carried out in a laboratory in which no provision was made for maintaining constant temperature; however, the variation in room temperature was not great. The arterial and venous pressures were determined at the beginning of the experiments. The apparatus used consisted of an ordinary venous pressure apparatus to which a small mercury U tube manometer had been attached. The venous pressure apparatus was con-

nected to the mercury manometer by means of a column of isotonic solution of sodium chloride. An 18 gage needle was inserted into one of the large veins of the forearm at the elbow; in most cases the median antecubital vein was used, although occasionally one of the other branches of the basilic or the cephalic vein was used. The needle was connected to the venous pressure apparatus and a three way stopcock interposed at the site of the needle, for the purpose of washing out the needle and the adjacent tubing between readings. The venous pressure apparatus was placed at approximately the level of the heart, and as soon as the normal pressure was determined the zero reading of the manometer was raised to the level of the venous pressure. One or 2 cc. of 2.5 per cent solution of sodium citrate was used to prevent clotting in the needle between readings.

Venous occlusion was obtained by an ordinary blood pressure cuff, applied about the upper part of the arm. The pressure to which the cuff was raised was in all cases approximately 10 mm. of mercury below the previously measured diastolic pressure. The remainder of the experimental procedure was carried out by two different methods. Although the differences between the two were slight and the results obtained were similar, for clarity of description the experiments may be referred to as groups 1 and 2. In the first group the blood pressure cuff was rapidly inflated to the desired level by means of a hand bulb, while in the second group the cuff was more rapidly inflated from a 15 gallon (58 liter) bottle reservoir. Observations were made at room temperature and during local application of controlled heat and cold to the extremity. Control of the temperature of the extremity was obtained in the first group by placing the hand and wrist, which were covered with an ordinary rubber glove, in a glass water bath in which the temperature was maintained constantly within plus or minus 1 degree of the desired level. In the second group of experiments a longer rubber glove was used than in the first group; thus the hand, the wrist and in addition the lower two thirds of the forearm were in the water bath. In all instances the extremity was allowed to remain in the water bath at least ten minutes before a reading was taken.

In both groups of experiments when the needle was inserted into the vein and the cuff inflated the venous pressure began to rise immediately. The rate of rise of the venous pressure was measured by means of a stopwatch graduated to the tenth of a second. Since the rate of rise was more uniform after the pressure had reached 20 to 25 mm. of mercury, in the first group of experiments the index chosen was the time required for the pressure to rise from 25 to 35 mm. of mercury. In the second group the index used was the time required for the pressure to rise from 0 to 40 mm. of mercury. Readings were made at frequent intervals. In the first group the extremity was observed at room

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temperature, and after several such readings the patient was instructed to exercise the hand and forearm by rapid repeated grippings for periods of two minutes. At the end of each two minute period the rate of rise in

the second group of experiments similar observations were made but in a different sequence. The effects of heat and cold were observed, followed by observations at room temperature and following exercise.

TABLE 1.—Results of the Experiments in Group 1\*

Patient and Condition	Reading	Room Temperature		Exercise and Room Temperature		Local Application of Cold			Local Application of Heat		
		Seconds Required for Venous Pressure Rise	Temperature, C.	Seconds Required for Venous Pressure Rise	Temperature, C.	Seconds Required for Venous Pressure Rise	Bath Temperature, C.	Room Temperature, C.	Seconds Required for Venous Pressure Rise	Bath Temperature, C.	Room Temperature, C.
G. B., aged 54; carcinoma of buccal mucous membrane; before operation	1	27.8	29.4	4.9	29.5	28.0	15.0	29.5	7.8	42.0	29.4
	2	17.8	29.5	5.4	29.5	37.0	15.6	29.3	7.3	42.2	29.5
	3	18.0	29.3	5.4	29.5	30.0	15.0	29.0	6.6	42.1	29.5
	4	16.2	29.5	6.6	29.4	37.7	15.1	29.4	6.8	41.8	29.6
	5	15.2	29.4	6.7	29.4	25.4	15.3	29.0	7.1	42.0	29.0
M. M., aged 46; nontoxic adenoma of thyroid; twelfth post-operative day	1	12.8	29.8	5.0	30.0	18.2	15.0	30.1			
	2	19.7	29.9	5.0	30.0	23.0	15.0	29.9			
	3	13.5	29.9	4.2	30.0	26.4	15.6	30.0			
	4	11.0	29.9	4.2	30.1	19.6	15.4	30.2			
	5	7.2	30.0	3.4	30.1	29.9	15.0	29.9			
	6	9.0	30.0								
	7	10.7	30.1								
R. P., aged 56; hemorrhoids; seventh post-operative day	1	63.0	26.6	1.9	27.6	31.1	10.5	27.6	7.3	42.0	27.3
	2	31.4	26.5	2.2	27.6	25.5	10.6	27.3	8.2	42.0	27.0
	3	24.0	26.8	4.2	27.7	20.0	11.0	27.0	8.9	42.9	27.4
	4	22.9	27.1	4.3	27.7	31.7	10.0	27.0	9.2	42.0	27.0
	5	23.6	27.2	3.3	27.7	27.0	10.1	26.5			
	6	13.5	27.3			37.9	10.5	27.0	8.2	41.5	26.8
	7	11.5	27.5								
	8	10.6	27.5								
	9	13.7	27.4								
	10	11.3	27.3								
V. V., aged 22; tumor of pharynx; before operation	1	9.5	27.5	6.1	27.6	22.2	15.0	27.6	9.0	42.0	27.3
	2	7.8	27.6	4.0	27.7	25.3	16.0	27.0	5.7	42.3	27.3
	3	10.4	27.5	4.2	27.8	38.4	15.1	27.3	6.0	42.1	27.2
	4	13.2	27.6	3.9	27.5	23.5	15.3	27.0	6.5	42.0	27.0
	5	11.5	27.6	2.6	27.8	33.0	14.9	27.4	6.2	41.9	27.8

\* The time in seconds required for venous pressure in the large veins of the forearm to rise from 25 to 35 mm. of mercury was determined. Observations were made at room temperature, followed by local application of cold and heat to the hand and wrist.

TABLE 2.—Results of the Experiments in Group 2\*

Patient and Condition	Reading	Local Application of Heat			Local Application of Cold			Room Temperature		Exercise and Room Temperature	
		Seconds Required for Venous Pressure Rise	Bath Temperature, C.	Room Temperature, C.	Seconds Required for Venous Pressure Rise	Bath Temperature, C.	Room Temperature, C.	Seconds Required for Venous Pressure Rise	Temperature, C.	Seconds Required for Venous Pressure Rise	Temperature, C.
R. H., aged 16; acute appendicitis; seventh postoperative day	1	22.3	39.8	25.3	41.0	20.1	25.3	28.5	25.5	5.2	25.0
	2	18.2	40.0	25.3	41.4	20.1	25.2	29.5	25.3	7.2	25.1
	3	16.8	39.6	25.1	47.0	20.0	25.4	24.0	25.3	5.0	25.0
	4	17.6	39.8	25.1	45.0	20.5	25.2	23.8	25.0	3.0	25.0
	5	16.5	40.0	25.1	55.4	20.2	25.0	24.9			
	6	18.4	40.0	25.0	60.0	20.3	25.5				
C. C., aged 47; stenosis of common bile duct; before operation	1	17.1	39.9	25.7	13.6	20.3	25.5	9.8	25.3	2.8	25.3
	2	9.0	39.0	25.5	15.3	20.3	25.3	11.1	25.3	3.4	25.3
	3	7.5	40.1	25.5	23.6	20.3	25.0	8.9	25.3	4.4	25.3
	4	7.0	39.7	25.5	31.5	20.4	25.0	11.5	25.3	3.4	25.4
	5	5.5	40.1	25.5	32.4	20.3	25.0	8.5	25.6		
	6	8.3	40.1	25.5	27.6	20.5	25.0				
J. D., aged 22; nasal deformity; before operation	1	16.8	39.5	25.7	16.2	19.7	25.7	19.9	27.1	4.6	25.3
	2	12.3	39.5	25.7	20.9	20.3	25.5	14.7	24.6	4.7	25.4
	3	12.8	39.3	25.7	24.1	19.8	25.5	12.6	25.7	4.5	25.7
	4	10.9	39.1	25.5	25.7	20.2	25.5	17.1	25.0	4.0	25.6
	5	13.8	39.8	25.5	28.2	20.8	25.5				
	6	12.1	40.1	25.7	25.9	20.2	25.5				
	7	10.4	39.5	25.3	37.1	20.6	25.0				

\* The time in seconds required for the venous pressure to rise from 0 to 40 mm. of mercury in the large veins of the forearm was determined. Observations were made on the effects of local application of heat and cold to the hand, the wrist and the lower two thirds of the forearm, followed by determinations at room temperature and following two minute periods of exercise.

venous pressure was observed and recorded. After several such readings the extremity was placed in a water bath at 10 or 15 C. and the rate of rise in venous pressure observed. This was followed by the same procedure with the water bath at 42 C. In

The results obtained were similar in both groups of experiments. Exact duplications of figures for various patients were not obtained, but similar trends were observed for all of them.

In all patients the initial rate of rise in venous pressure was slower than the rate in succeeding determinations. This increase in rapidity of rise quickly reached a fairly uniform rate and remained there. It has been observed by Freeman<sup>2a</sup> and others that the blood flow in an extremity is greatly influenced by changes in temperature of the extremity; the application of heat increases the blood flow, while the application of cold decreases it. In the experiments described here the application of heat in all cases increased the rate of rise of the venous pressure, an observation which coincides with that of Freeman and others. Likewise, the application of cold to the extremity invariably produced a decrease in the rate of rise in venous pressure. Exercise of the muscles of the forearm and hand for two minutes produced a pronounced increase in the rate of rise in venous pressure, the increase being greater than that produced by the local application of heat (40 to 42 C.).

#### COMMENT

These observations indicate that the rate of rise in venous pressure in the large veins of the forearm reflects to some degree the rate of blood flow in an extremity. When the venous outflow from an extremity is suddenly occluded by a pressure lower than the diastolic pressure, the arterial inflow continues. The incoming blood progressively distends the arterial, capillary and venous systems, increasing the volume in the arm. The initial rapid arterial inflow represents the normal rate of inflow. Gradually this rate decreases as the pressure rises in the capillary and venous systems. The rise in pres-

sure in the venous system, as measured in these experiments, is probably a later phase in the process than the initial increase of volume, which is used as an index in the plethysmographic methods. The brief period required for the filling of the vascular system is apparent when one observes the mercury manometer; the initial rise is slower than the more rapid steady rise which quickly follows. Subsequent studies will be made in order to compare the pressure curves obtained by this method with the curves obtained by the plethysmographic methods and to determine the possible variations produced by elasticity of the vessel walls, vasomotor tone, skeletal muscle tone and tissue pressure.

The exact relationship between the results obtained by the plethysmographic methods and the results obtained in these experiments is difficult to state, since different units of measurement are used. However, these experiments give some indication of the blood flow, since factors which previously have been shown to alter the rate of blood flow in an extremity produced identical responses in these experiments.

#### SUMMARY

In the experiments described here the measurement of the rate of rise in venous pressure in the large veins of the forearm following venous occlusion is, at least to some extent, an index of the rate of blood flow in the extremity. Local application of heat to the hand and forearm and exercise of the muscles of the hand and forearm increase the rapidity of rise in venous pressure, while local application of cold decreases it.

# INTRAVENOUS ADMINISTRATION OF DEXTROSE IN THE TREATMENT OF PATIENTS WITH DISEASE OF THE BILIARY TRACT

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Determination of the glycogen and lipid content of samples of liver obtained from patients in the course of operations on the biliary tract indicated that the diet high in carbohydrate and protein advocated by us<sup>1</sup> was more effective in decreasing the fat content of the liver than in elevating the glycogen content. The present study was undertaken to determine the effectiveness of intravenous administration of dextrose during the twelve hours preceding operation in increasing liver glycogen in patients with disease of the biliary tract.

The value of giving intravenous infusions of dextrose solution to patients with disease of the biliary tract in preparation for surgical treatment has at times been overemphasized. Nevertheless, when used as a supplement to a suitable diet and not as a substitute for diet they appear to be useful. Many of these patients show histologic evidence of hepatic damage at operation, and it seems of particular interest to determine whether a high level of liver glycogen would be found in such patients after infusion of dextrose.

## PROCEDURE

Eighteen patients with varying degrees of disease of the biliary tract requiring surgical operation were studied. Two liters of 10 per cent dextrose solution was administered to each patient by continuous venoclysis for about twelve hours preceding operation. The operative procedure was carried out with the patient

under spinal anesthesia in every instance. At the of each operation approximately 0.5 Gm. of tissue removed from the anterior margin of the liver, a portion of this specimen was immediately placed in potassium hydroxide solution for determination of glycogen. Chemical and histologic analyses were made of all specimens removed. After removal of the portion of the specimen for determination of glycogen, remainder of the specimen was divided into two equal parts, one for histologic study and the other for determination of fat content. Determinations of liver glycogen were made by the method of Good, Kramer and Somogyi.<sup>2</sup> Mam and Long's<sup>3</sup> modification of Stoddard and Drury<sup>4</sup> method was used for determinations of fat.

## RESULTS

Biopsy specimens of the liver from 58 patients with disease of the biliary tract were studied. Eighteen of the patients received dextrose intravenously prior to operation. The average liver glycogen content of the liver of those patients was 6.1 per cent. The highest value observed in this group was 10 per cent, and the lowest was 3 per cent. In analyses of biopsy specimens of the liver of a group of 40 other patients with disease of the biliary tract who were not treated with dextrose administered intravenously, the average glycogen content was 2.8 per cent. Thus the average glycogen content of the liver in the group of patients treated with intravenous administration of dextrose was 118 per cent higher than that in the group of 40 patients who did not receive dextrose intravenously.

Those of the 18 patients who were given dextrose intravenously and who had histologic evidence of some hepatic damage had an average liver glycogen level of 5.7 per cent. This level of 5.7 per cent was 104 per cent higher than the

From Surgical Service B, Hospital of the University of Pennsylvania and The Harrison Department of Surgical Research, University of Pennsylvania School of Medicine.

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average glycogen level of the control group. Thus it is possible to produce a significant elevation of the glycogen content of the liver in the presence of moderate hepatic damage. None of the patients studied had histologic evidence of severe hepatic damage.

#### COMMENT

It has long been recognized that the damaged liver contains an increased amount of fat and little glycogen.<sup>5</sup> Rosenfeld<sup>6</sup> demonstrated that animals fed on carbohydrate are less susceptible to drugs which cause hepatic damage and increase in liver fat and furthermore that once hepatic damage is established recovery is aided by feeding of carbohydrate. Davis, Hall and Whipple,<sup>7</sup> Opie and Alford<sup>8</sup> and Graham<sup>9</sup> demonstrated experimentally the resistance of liver containing increased amounts of glycogen to hepatic damage produced by chloroform or phosphorus. A high carbohydrate intake was shown by Bollman and Mann,<sup>10</sup> Ravdin,<sup>11</sup> and others to reduce the degree of hepatic damage following experimental ligation of the common bile duct.

Large quantities of dextrose were first used at the suggestions of Beddard<sup>11</sup> for the treatment of patients with hepatic damage following chloroform anesthesia. Jones<sup>12</sup> found that the more intensive the dextrose therapy the better the prognosis for patients with acute hepatic insufficiency. Regardless of whether or not carbohydrate acts directly or indirectly in protecting the liver against damage or in aiding recovery, if damage has already occurred carbohydrate has come to be regarded as of value clinically.

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There have been differences of opinion among the proponents of carbohydrate therapy concerning the advantages of intravenous administration of dextrose if the patient is able to take large amounts of carbohydrate by mouth. MacIntyre and associates<sup>13</sup> have shown that supplementary dextrose given by mouth will raise the glycogen content of the normal liver, but they were not successful in raising the glycogen level of the severely damaged liver above 2.9 per cent. which is approximately the average normal glycogen content of the undamaged liver. More carbohydrate can be deposited in the liver if dextrose is given by the intravenous route than if an equivalent amount is given by mouth. The explanation for this probably lies in the fact that higher blood sugar levels are obtained when dextrose is administered by vein than when administered by mouth. Cori and Cori<sup>14</sup> have pointed out that the blood sugar level to a large extent determines the amount of glycogen deposited in the liver and that this deposition is not determined by the total amount of dextrose administered.

This fact can be further demonstrated in this experiment if our data are compared with those of MacIntyre and associates.<sup>13</sup> In each experiment the same amount of dextrose was used, namely 200 Gm. MacIntyre's patients received this amount by mouth during the twelve hours preceding operation, whereas the patients reported on here received the same amount intravenously during the twelve hours preceding operation in the form of 2,000 cc. of 10 per cent dextrose. The patients who received dextrose by mouth showed a 60 per cent increase in liver glycogen, while those who received dextrose intravenously showed an increase of 118 per cent. Thus when 200 Gm. of dextrose is administered by vein a higher glycogen content results than when the same amount is given by mouth.

Goldschmidt, Vars and Ravdin<sup>15</sup> demonstrated that the degree of hepatic damage following chloroform anesthesia is proportional to the fat content of the liver. They concluded that a higher concentration of hepatic glycogen, per se, fails to confer any discernible protection against the hepatotoxic action of chloroform in rats with the same concentration of hepatic fatty acids and similar intakes of protein. Johnson and

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co-workers<sup>15</sup> showed that a diet high in protein and carbohydrate and low in fat was as effective in one week in reducing liver fat in the dog with obstructive jaundice as a high carbohydrate diet was in two weeks. Protection of the liver against damage, therefore, resolves itself into the positive action of protein, the indirect action of carbohydrate and the negative action of fat.

The results of administration of a diet high in carbohydrate and protein, low in fat and high in calories for five days or more before operation, while excellent from the standpoint of reducing the fat content of the liver, were not impressive from the standpoint of the degree of elevation of the glycogen level. The average increase of liver glycogen after such a diet in patients with severe hepatic damage was 10 per cent.<sup>16</sup> On the other hand, there was no evidence in the patients who received dextrose intravenously that the fat content was significantly lowered.

In the light of these findings, the optimum preparation of patients with hepatic damage for surgical operation would probably be obtained with administration of a diet high in protein and carbohydrate and low in fat over five to fourteen days, supplemented by intravenously administered dextrose for a period immediately prior to operation.

The need for dextrose preoperatively in patients with hepatic damage becomes more apparent when one realizes that as much as 45 per cent of the liver glycogen may be lost during

the course of a long operation, as reported by Ariel, Pack and Rhoads.<sup>16</sup>

Liver glycogen is so labile that if one desire to maintain it at a high level during an operation intravenous administration of dextrose is fully justified, especially during the period of fasting immediately before operation. Its administration may, of course, be continued throughout the operation and into the postoperative period.

#### SUMMARY

Biopsy specimens of the liver were taken from a group of 58 patients with disease of the biliary tract. Eighteen of these patients received dextrose intravenously before operation, and the remaining 40 patients were controls and received no preoperative dextrose therapy intravenously.

The average glycogen level of the liver of the patients who received dextrose intravenously was 6.1 per cent, or 118 per cent greater than the average glycogen level of the control group.

The patients who had moderate hepatic damage, as judged by histologic studies, and who received dextrose intravenously had an average hepatic glycogen level of 5.7 per cent, or 104 per cent more than the level observed in the control patients.

Intravenous administration of dextrose without dietary supplement did not significantly lower the fat content of the liver in the patients observed.

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# SUBARACHNOID ANALGESIA MAINTAINED BY THE CONTINUOUS DROP METHOD

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The method for inducing continuous spinal anesthesia introduced by Lemmon<sup>1</sup> in 1940 has no drugs, the procedure for obtaining subarachnoid analgesia. This has greatly increased its adaptability and safety. Recently we<sup>2</sup> described a continuous drop method for maintaining subarachnoid analgesia.

## TECHNIC

In addition to the special mattress, malleable needle, tubing and stopcock of Lemmon, the equipment includes 250 cc. leveling flask and tubing fitted with a Murphy stopper, a regulating valve and a glass adapter (fig.). After the lumbar puncture is accomplished and the patient turned to the recumbent position, the initial dose of anesthetic solution is given, as would be done with the fractional method of administration. For this dose we use 2.5 per cent procaine hydrochloride in a 2.5 per cent solution of dextrose in isotonic solution of sodium chloride. The size of the initial dose depends on the site of analgesia desired. For a cutaneous level to the third or fourth thoracic segment, which is adequate for an operation on the upper part of the abdomen, a good risk patient of average size will require 6 cc. of the solution, representing 150 mg. of procaine hydrochloride. As soon as the initial injection is made, the patient is placed in a 5 degree Trendelenburg position and analgesia is established at the necessary level. The patient is then moved to the operating room, the operative field prepared and the incision made. Analgesia is maintained by the drop method. The leveling flask, containing 0.5 per cent procaine hydrochloride solution, is suspended 60 to 80 cm. above the level of the spinal needle. Twenty minutes after administration of the initial dose, the 2 cc. of the 2.5 per cent procaine hydrochloride solution remaining in the continuous spinal tubing (measured to contain exactly that amount) is withdrawn. The air is exhausted from the tubing of the leveling flask by permitting it to fill with 0.5 per cent procaine hydrochloride solution, and then the glass adapter is connected to the stopcock. Forty drops of the 0.5 per cent procaine solution is run in immediately to replace the 2 cc. of the 2.5 per cent procaine solution previously withdrawn. By calibration 20 drops of this solution represents 1 cc. Then the valve is regulated

to deliver the desired number of drops per minute. The rate of dropping should be accurately timed by a stopwatch. For work on the upper part of the abdomen in the average patient it is necessary to adjust the flow to the rate of 8 drops per minute. If a lower level of analgesia is indicated or the patient is small, the rate should be slower. It is advisable to test the cutaneous level at intervals, in order to be assured that it has neither advanced nor receded. The rate of dropping may vary slightly with changes in the pressure of the spinal fluid. Usually it tends to become gradually slower. This should be checked every ten or fifteen minutes and the valve regulated to deliver the drops at the desired rate. Occasionally, although working

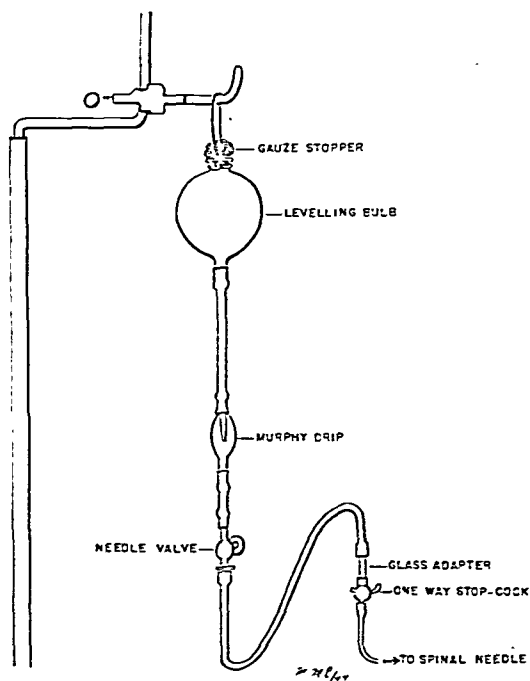


Diagram of apparatus.

conditions have been satisfactory throughout, additional relaxation is needed to close the peritoneum. This may be immediately obtained by letting 100 drops (representing 25 mg. of procaine in 5 cc.) go in rapidly. Then dropping is resumed at the usual rate and continued until the cutaneous stitches are started.

The table contains a summary of the management of the first 27 consecutive cases in which the continuous drop method was used. In 11 cases the spinal anesthesia was supplemented with pentothal sodium to produce sleep and obtund the vomiting and traction reflexes. Usually the blood pressure was well maintained without the aid of adrenergic drugs, but it was necessary to give such a drug in 9 cases.

From the Department of Anesthesia of the Massachusetts General Hospital and the Anesthesia Laboratory of the Harvard Medical School at the Massachusetts General Hospital.

1. Lemmon, W. T.: A Method for Continuous Spinal Anesthesia, *Ann. Surg.* **111**:141-144, 1940.

2. Arrowood, J. G., and Folds, F. F.: A Continuous Drop Method for Subarachnoid Analgesia, *Anesthesiology* **5**:465-469, 1944.

*Summary of the Results of the Continuous Dro.*

No.	Name	Sex	Age, Yr.	Diagnosis	Operative Procedure	Premedication,* Mg.	Dose, Mg.		Spinal Level	Duration Hr. Min.
							Initial	Total		
1	R. C.	♀	39	Intestinal polyposis	Removal of polyps	M.S. 10.0 A.S. 0.6 E.S. 50.0	100	190	Second dorsal	1 20
2	C. O.	♂	57	Carcinoma of perianal region	Radical dissection of left groin	Pento. 100.0 M.S. 10.0 A.S. 0.6 E.S. 50.0	100	255	Fifth dorsal	2 55
3	J. R.	♂	52	Carcinoma of bladder	Right uretero-enterostomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	125	355	Third dorsal	2 ..
4	A. P.	♂	64	Inguinal hernia	Gallie herniorrhaphy	M.S. 10.0 Scop. 0.3 E.S. 50.0	100	300	Sixth dorsal	2 45
5	A. G.	♂	58	Carcinoma of stomach	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	720	Third dorsal	4 10
6	J. M.	♂	68	Duodenal ulcer	Second stage gastric resection	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	260	Second dorsal	1 35
7	E. K.	♂	63	Duodenal ulcer	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	535	Second dorsal	3 50
8	R. K.	♂	18	Duodenal ulcer	Second stage gastric resection	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	350	Third dorsal	2 10
9	C. C.	♀	60	Metastatic carcinoma of vulva	Radical dissection of groin	M.S. 10.0 A.S. 0.6 E.S. 50.0	100	320	Fifth dorsal	3 30
10	G. P.	♂	24	Ventral hernia	Gallie repair	M.S. 10.0 A.S. 0.6 E.S. 50.0	125	425	Fourth dorsal	4 15
11	E. M.	♀	65	Carcinoma of vulva	Radical dissection of groin	M.S. 10.0 A.S. 0.6 E.S. 50.0	100	370	Fourth dorsal	3 40
12	C. S.	♀	60	Carcinoma of the cecum	Colectomy (right side)	M.S. 10.0 A.S. 0.6 E.S. 50.0	125	340	Third dorsal	3 ..
13	T. P.	♂	46	Obstructing duodenal ulcer	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	650	Fourth dorsal	4 15
14	S. N.	♂	52	Duodenal ulcer stomach	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 P.S. 150.0 E.S. 50.0	150	570	Third dorsal	3 55
15	N. N.	♀	63	Carcinoma of left side of colon	Resection of the descending colon	M.S. 8.0 A.S. 0.6 P.S. 150.0 E.S. 50.0	125	275	Third dorsal	2 5
16	G. M.	♂	63	Carcinoma of the bladder	Bilateral uretero-enterostomy	M.S. 15.0 A.S. 0.6 E.S. 50.0	150	370	Fourth dorsal	2 15
17	C. S.	♀	67	Carcinoma of the ascending colon	Ileotransverse colostomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	125	265	Third dorsal	2 40
18	J. M.	♂	63	Jejunal ulcer	Subtotal gastric resection	M.S. 8.0 Scop. 0.3 Pento. 100.0	150	390	Third dorsal	2 25
19	J. H.	♂	56	Carcinoma of the stomach	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	550	Third dorsal	3 50
20	M. E.	♀	53	Carcinoma of the stomach	Exploratory laparotomy and biopsy	M.S. 10.0 A.S. 0.4 E.S. 50.0	150	180	Third dorsal	1 ..
21	F. M.	♂	45	Gastric ulcer	Subtotal gastrectomy	M.S. 10.0 A.S. 0.6 E.S. 50.0	150	450	Third dorsal	2 35
22	O. D.	♂	31	Duodenal ulcer	Second stage gastric resection	M.S. 10.0 A.S. 0.6 E.S. 50.0	200	420	Third dorsal	2 15
23	J. M.	♂	63	Aneurysm of common femoral artery	Excision of aneurysm	M.S. 10.0 A.S. 0.6 E.S. 50.0	125	200	Sixth dorsal	1 10
24	M. F.	♂	62	Carcinoma of splenic flexure	Resection of splenic flexure	M.S. 8.0 A.S. 10.0 Pento. 100.0 E.S. 75.0	125	250	Fourth dorsal	2 ..
25	F. D.	♂	72	Carcinoma of rectum	Combined abdominal perineal resection	M.S. 8.0 A.S. 0.6 E.S. 50.0	150	555	Sixth dorsal	6 55
26	M. B.	♂	42	Intestinal obstruction	Plication of cecum	M.S. 10.0 A.S. 0.6 Pento. 100.0 E.S. 50.0	150	165	Third dorsal	1 ..
27	E. S.	♂	63	Aneurysm of left femoral artery	Excision of aneurysm and repair of inguinal hernia	M.S. 8.0 A.S. 0.4 E.S. 25.0	100	165	Fifth dorsal	1 40

\* M.S. indicates morphine sulfate; A.S., atropine sulfate; E.S., ephedrine sulfate; Pento., pentobarbital sodium; Scop., scopolamine hydrobromide, and P.S., phenobarbital sodium.

Method in the First Twenty-Seven Consecutive Cases

Intravenous Therapy †	Pentothal Sodium, Gm.	Adrenergic Drug ‡	Operative Complications	Postoperative Complications	Comments
5% D. in W.	....	.....	.....	.....	Patient had 6 major abdominal operations previously for recurrent intestinal polyposis and its complications
5% D. in S.	....	Pit. 5 units E.S. 25 mg.	Moderate fall in blood pressure; slight nausea	Moderate nausea and emesis on first postoperative day	Patient had a previous combined abdominal perineal resection; moderate anemia (R. C. 3,750,000); for maintenance of anesthesia 0.3% instead of 0.5% procaine hydrochloride was used
5% D. in S.	....	.....	.....	.....	After 1 hr. 25 min. of anesthesia, relaxation became poor; administration of 120 drops (6 cc. = 30 mg.) of 0.5% procaine hydrochloride solution within 1 min. resulted in complete relaxation
.....	....	.....	.....	.....	
5% D. in S. + 500 cc. blood	1.0	.....	.....	.....	Besides the usual 8 drops of 0.5% procaine hydrochloride per minute, the patient four times received 100 drops (5 cc. = 25 mg.) of same solution dropped in rapidly
.....	0.6	Pit. 5 units E.S. 25 mg.	Moderate fall in blood pressure after 20 min.	.....	
500 cc. blood	....	.....	.....	.....	
.....	....	.....	.....	.....	
5% D. in W.	....	.....	.....	.....	
.....	....	.....	.....	Nausea and vomiting on operative day	
.....	....	.....	.....	Nausea on operative day	
5% D. in W.	0.55	3 mg. Neo. intramuscularly twice	Fall in blood pressure	.....	
500 cc. blood	1.7	.....	.....	.....	
500 cc. blood	1.4	.....	.....	.....	
500 cc. blood	0.4	.....	.....	.....	After 1 hr. 40 min. of anesthesia 100 drops (5 cc. = 25 mg.) of 0.5% procaine hydrochloride solution was administered for inadequate relaxation
5% D. in S.	....	Pit. 5 units E.S. 25 mg. intramuscularly	Fall in blood pressure	.....	
500 cc. blood	....	Pit. 5 units E.S. 25 mg. intramuscularly	Fall in blood pressure	.....	
500 cc. blood	1.1	.....	.....	.....	
1,000 cc. blood	....	Pit. 5 units E.S. 25 mg. intramuscularly twice	Fall in blood pressure	.....	
500 cc. blood	....	.....	.....	.....	
500 cc. blood	0.75	.....	.....	.....	
N.S.	0.8	.....	.....	.....	Patient was 6 ft. 3 in. (1.9 m.) tall, and initial dose had to be increased to 200 mg. to obtain satisfactory height of anesthesia
500 cc. blood	....	.....	.....	.....	
500 cc. blood	....	.....	.....	.....	Patient was extremely obese, had been operated on previously for carcinoma of uterus and was anemic; blood pressure at start was 80/55 mm. Hg
2,500 cc. blood + 500 cc. plasma	1.25	Pit. 5 units E.S. 25 mg. intramuscularly Neo. 1 mg. intravenously twice	Fall in blood pressure; severe loss of blood	Nausea and vomiting on operative and first postoperative day	Before turning patient to Sims position 6 mg. of tetracaine hydrochloride in 2 cc. of 2.5 D. in S. was given and the spinal needle removed
N.S.	0.3	Neo. 1 mg. intravenously twice	Fall in blood pressure	.....	
N.S. + 500 cc. blood	....	Pit. 5 units E.S. 25 mg. subcutaneously	Fall in blood pressure	Chill attributed to transfusion	Anesthesia maintained with 0.3% procaine hydrochloride solution

† D. in W. indicates dextrose in water; D. in S., dextrose in saline solution and N.S., isotonic solution of sodium chloride.  
‡ Pit. indicates pitressin and Neo., neo-syneprhine hydrochloride.



## COMMENT

With any method involving fractional dosage, the concentration of the anesthetic drug in the spinal fluid is higher immediately after injection of each dose and gradually decreases until the next dose is given. Corresponding to this, the level of analgesia advances and recedes. By the continuous drop method, after the analgesia is established at the desired height, it can be kept there constantly by administering a dilute solution at a suitable rate.

Accidents and undesirable side effects occurring in the course of spinal analgesia are directly related to: (a) the inherent toxicity of the drug used; (b) the size of the individual dose, and (c) the concentration of the drug in the injected solution. The first factor can be reduced to a minimum by using the least toxic local anesthetic available. At the present time pharmacologists are agreed that this agent is procaine hydrochloride. The size of each dose can be reduced with any method of fractional administration, but with such a method each dose must be large enough to produce a concentration at the uppermost anesthetized segment sufficient to produce an analgesia that will last until the next dose. With a more sensitive method, such as the continuous drop technic, after the necessary level of analgesia is established by the initial dose it is possible to add only that amount of the drug necessary to maintain this level from moment to moment. This keeps the concentration of the drug in the spinal fluid at a minimum at all times.

By no means the least important advantage of the drop method is that it provides a perfectly aseptic technic. After it is once connected, the

system can be kept closed at all times, there is no necessity for changing a syringe or undergoing other manipulations.

The volume of 0.5 per cent procaine hydrochloride solution injected in the course of operation varies between 15 and 25 cc. in an hour. It was thought possible that this might result in a serious rise in the pressure of the spinal fluid in operations lasting two hours or more. For this reason a spinal fluid manometer was included in the system in 8 early cases, and readings were taken initially and every ten minutes throughout. A slight gradual sustained rise was observed, which caused no symptoms and was without clinical significance.

Although the apparatus for continuous drop spinal anesthesia can be adjusted to maintain analgesia with little supervision, the safety of the technic depends on its meticulous application and on expert observation and management of the patient. We therefore advise that it be used only by the experienced spinal anesthetist who can give it his undivided attention. It should not be initiated by the surgeon for later supervision by a nurse anesthetist or an intern.

## SUMMARY

A continuous drop method for maintaining spinal analgesia is described. The advantages of such a technic are:

1. The level of analgesia can be kept constant.
2. The safety factor is increased because the size of the dose and the concentration of the drug in the spinal fluid can be kept at a minimum.
3. Continuous administration makes it possible to use the least toxic drug.
4. Complete asepsis may be assured.

# PENICILLIN IN THE TREATMENT OF CHRONIC OSTEOMYELITIS

## A REPORT OF FORTY CASES

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BOSTON

It is now generally accepted that penicillin is the most effective chemotherapeutic agent yet discovered for the treatment of staphylococcal infections. In view of this fact, a critical study of its action on chronic osteomyelitis should be of value.

Such a study should have two aims: one to evaluate the effectiveness of penicillin for this disease and the other to determine, if possible, the most satisfactory method of employing this new therapeutic agent. In any study of chronic osteomyelitis, prolonged observation of patients after the completion of treatment is necessary before final conclusions can be established.

Several reports have now been published in which reference has been made to the use of penicillin for chronic osteomyelitis.<sup>1</sup> These reports have been concerned chiefly with a description of the immediate effect of penicillin. There has been no report as yet of a series of cases in which it has been possible to follow the course of the disease for any considerable time after the completion of treatment.

From the Robert Dawson Evans Memorial of the Massachusetts Memorial Hospitals and the Departments of Medicine and Orthopedic Surgery, Boston University School of Medicine.

The penicillin was provided by the Office of Scientific Research and Development from supplies assigned by the Committee on Medical Research for clinical investigations recommended by the Committee on Chemotherapeutics and Other Agents of the National Research Council.

1. Florey, M. E., and Florey, H. W.: General and Local Administration of Penicillin, *Lancet* 1:388 (March 27) 1943. Keefer, C. S.; Blake, F. G.; Marshall, E. K., Jr.; Lockwood, J. S., and Wood, W. B., Jr.: Penicillin in the Treatment of Infections, *J. A. M. A.* 122:1217 (Aug. 28) 1943. Lyons, C.: Penicillin Therapy of Surgical Infections in the U. S. Army, *ibid.* 123:1007 (Dec. 18) 1943. Robertson, I. M.: Penicillin in Bone Infections, *Brit. M. J.* 1: 519 (April 15) 1944. Mowlem, R.: Surgery and Penicillin in Mandibular Infections, *ibid.* 1:517 (April 15) 1944. Dawson, M. H., and Hobby, G. L.: The Clinical Use of Penicillin, *J. A. M. A.* 124:611 (March 4) 1944. Barr, J. S.: The Use of Penicillin in the Navy, *J. Bone & Joint Surg.* 26:380 (April) 1944. Ferrer, J. M., Jr.: The Role of Penicillin in the Management of Infection, *ibid.* 26:522 (July) 1944.

The purpose of this paper is to present a preliminary report of a series of 40 cases of chronic osteomyelitis in which treatment with penicillin has been employed. In 25 of these cases, it has been possible to conduct follow-up observations for one year or longer after completion of the first course of treatment with penicillin. The results of treatment will be presented, and the methods of treatment which we have found to be most satisfactory will be discussed.

### CLINICAL MATERIAL

The pertinent data concerning the history, treatment and results of treatment in each case are summarized in table 1.

The patients ranged in age from 14 to 74 years. Thirty-four (85 per cent) were over 20 years of age. The duration of the osteomyelitis varied from two months to forty-nine years. In all but 6 cases it was of more than one year, and in 17 it was of more than ten years. At the time treatment with penicillin was begun, symptoms and signs of active infection had been present for from one week to eighteen years. In 19 cases (47 per cent) draining sinuses had been present for one year or longer.

Most of the patients had received intensive therapy with sulfonamide drugs without benefit, and many of them had had recent surgical treatment. One half of the patients had definite constitutional symptoms, such as fever, malaise and anorexia.

The site of infection was the femur in 25 cases, the humerus in 4, the tibia in 4, the sacrum in 2, the radius in 2 and in 1 each the ulna, the metatarsal bones and the vertebrae. In 35 cases, draining sinuses were present. In the other 5 abscesses of the bone or soft tissues which had not drained were present.

*Staphylococcus aureus* was cultured from material from the local lesion in all but 2 cases. In 2 cases (cases 31 and 36) abscesses were not drained until penicillin had been given for several days. Material taken for culture at the time of operation was sterile. In each of these

instances *Staph. aureus* had been cultured from material from the lesion during a previous exacerbation.

In 6 cases (cases 2, 23, 25, 27, 29 and 33) beta hemolytic streptococci were also cultured,

isolated from patients before treatment with penicillin was begun (table 2). The tests were performed by the method described by one of us elsewhere.<sup>2</sup> Twenty-four strains were completely inhibited by concentrations of 0.08 Ox-

TABLE 1.—Pertinent Data on Forty Cases of Chronic Osteomyelitis in Which Treatment with Penicillin Was Used

Case	Age, Yr.	History Bone Involved	History				Treatment						Results	
			Duration of Osteomyelitis, Yr.	Duration of Drainage, Wk.	Sequestrums	Duration, Days		Average Daily Dose, Oxford Units		Surgical Treatment	Cultures Sterile, Days	Sinuses Healed, Days	Follow-Up Observations	
						Systemic	Local	Systemic	Local					
1	36	Femur.....	23	2	+	28	0	30,000	0	0	17	42	Well at 21 mo.	
2	26	Fourth and fifth lumbar vertebrae	1	52	0	6	5	90,000	2,000	0	3	11	Well at 20 mo.	
3	44	Femur.....	32	52	0	16	0	75,000	0	0	9	20	Well at 14 mo.	
4	53	Femur.....	13	1†	0	21	0	120,000	0	0	7	12	Well at 4 mo.	
5	55	Femur.....	25	20	0	14	0	100,000	0	0	5	7	Well at 11 mo.	
6	27	Sacrum.....	3	104	0	20	15	70,000	4,000	0	11	41	Well at 16 mo.	
7	37	Femur.....	29	2	0	23	0	200,000	0	0	17	26	Well at 3 mo.	
8	35	Humerus.....	2	104	0	15	0	120,000	0	0	?	14	Well at 5 mo.	
9	27	Femur.....	14	2	0	13	0	75,000	0	0	17	31	Relapsed at 15 mo.†	
10	41	Femur.....	7 mo.	25	+	19	0	100,000	0	0	14	15	Relapsed at 2 mo.‡	
11	27	Femur.....	12	5	+	25	0	110,000	0	0	Never	58	Relapsed at 6 mo.‡	
12	58	Femur.....	49	104	+	17	0	80,000	0	0	11	45	Relapsed at 3 mo.	
13	36	Tibia.....	10	40	0	24	7	75,000	500	0	21	Never	Failure	
14	23	Humerus.....	5	260	+	25	0	100,000	0	0	Never	Never	Failure	
15	24	Femur *.....	16	1	0	2	0	360,000	0	0	Never	Never	Died	
16	45	Femur.....	6	2	0	18	0	75,000	0	0	13	17	Relapsed at 4 mo.	
		2d course *.....	..	2	0	25	0	120,000	0	0	?	14	Well at 11 mo.	
17	35	Femur.....	8	26	+	22	0	100,000	0	0	14	39	Relapsed at 3 mo.	
		2d course.....	..	2	+	24	0	100,000	0	0	5	28	Relapsed at 4 mo.	
18	53	Femur.....	2	6†	0	16	0	75,000	0	0	?	20	Relapsed at 7 mo.	
		2d course *.....	..	2†	0	16	0	120,000	0	0	?	16	Well at 9 mo.	
19	36	Tibia.....	1½	68	0	16	0	60,000	0	0	11	30	Relapsed at 2 mo.	
20	21	Femur.....	7	364	0	23	0	70,000	0	0	11	Never	Improved	
		2d course *.....	..	404	0	55	0	120,000	0	0	14	Never	Improved	
21	31	Femur.....	8	34	0	6	0	65,000	0	0	4	24	Relapsed at 4 mo	
		2d course.....	..	2	0	15	0	100,000	0	0	16	35	Relapsed at 12 mo.‡	
22	17	Femur.....	5 mo.	20	+	56	14	30,000	4,000	0	Never	Never	Failure	
23	47	Femur.....	41	520	+	20	3	30,000	3,000	0	Never	Never	Failure	
24	32	Femur.....	11	78	+	14	0	30,000	0	0	8	16	Relapsed at 1 mo.	
25	69	Sacrum.....	2	156	+	55	0	90,000	0	0	Never	Never	Improved	
26	47	Tibia.....	33	52	+	6	0	70,000	0	0	4	23	Relapsed at 1 mo.	
		2d course.....	..	6	0	11	0	80,000	0	0	?	7	Well at 9 mo.	
27	16	Femur.....	5	260	+	25	0	75,000	0	0	Never	21	Relapsed at 6 mo.	
		2d course.....	..	2	+	31	10	120,000	20,000	+	Never	23	Well at 6 mo.	
28	58	Femur.....	3	104	0	21	0	30,000	0	0	14	34	Relapsed at 6 mo.	
		2d course.....	..	1	0	29	10	60,000	40,000	+	10	56	Well at 16 mo.	
29	36	Femur.....	24	90	+	20	7	50,000	30,000	+	8	15	Well at 17 mo.	
30	14	Femur.....	4 mo.	16	+	17	12	60,000	10,000	+	10	23	Well at 17 mo.	
31	15	Femur.....	4	4†	0	44	8	80,000	50,000	+	?	44	Well at 10 mo.	
32	28	Ulna.....	21	6†	0	36	10	100,000	15,000	+	3	42	Well at 9 mo.	
33	42	Femur.....	7	364	+	27	9	120,000	20,000	+	Never	33	Well at 4 mo.	
34	74	Metatarsus.....	2 mo.	8	+	31	10	120,000	10,000	+	15	56	Well at 3 mo.	
35	14	Humerus.....	2 mo.	6	+	26	11	120,000	20,000	+	20	33	Well at 5 mo.	
36	22	Radius.....	4	16†	0	26	10	120,000	10,000	+	?	26	Well at 3 mo.	
37	29	Humerus.....	26	312	+	23	10	120,000	20,000	+	8	31	Well at 3 mo.	
38	15	Radius.....	2	1	+	9	14	50,000	4,000	+	?	24	Relapsed at 13 mo.‡	
39	33	Femur.....	18	15 yr.	+	29	0	120,000	0	+	Never	25	Relapsed at 1 mo.	
		2d course.....	..	2	+	40	16	200,000	40,000	+	34	41	Well at 2 mo.	
40	51	Tibia.....	5 mo.	12	+	29	10	200,000	30,000	+	Never	Never	Failure	

\* A blood culture was positive for *Staph. aureus* at the beginning of treatment.

† The figure refers to the duration of symptoms from an undrained abscess.

‡ The organism became resistant to penicillin.

§ The lesion healed spontaneously shortly after the relapse; it was healed at the time of writing.

and in 6 cases (cases 9, 19, 22, 23, 25 and 33) various gram-negative bacilli were present in addition to staphylococci. When the patients first presented themselves for treatment with penicillin only 1 (case 15) had bacteremia.

It was possible to test the susceptibility to penicillin of thirty-two strains of *Staph. aureus*

ford unit in 1 cc. of medium or less. For the other eight strains slightly higher concentrations of penicillin were necessary to effect complete inhibition, but none of the strains isolated before

2. Rammelkamp, C. H., and Maxon, T.: Resistance of *Staphylococcus Aureus* to the Action of Penicillin. *Proc. Soc. Exper. Biol. & Med.* 51:386 (Dec.) 1942

treatment was resistant to the action of penicillin.

TABLE 2.—*Susceptibility to Penicillin of Thirty-Two Strains of Staph. Aureus Isolated from Patients with Chronic Osteomyelitis Before Treatment with Penicillin*

Minimal Concentration of Penicillin Completely Inhibiting Growth (Oxford Units in 1 Cc. of Medium)	Number of Strains
0.01.....	2
0.02.....	4
0.04.....	6
0.08.....	12
0.17.....	7
0.35.....	1
Total.....	32

#### TREATMENT

In 31 of the 40 cases included in this study, only one course of penicillin therapy was given, while in 9 penicillin was given on two separate occasions. We shall consider first the initial course of penicillin therapy. Later we shall analyze the results of the second course in the 9 cases in which additional treatment was given.

*First Course of Treatment.*—All the patients received penicillin by intravenous or intramuscular injections at intervals of three or four hours. A few received a portion of the penicillin by continuous intravenous infusion.

In our experience the use of penicillin locally without simultaneous parenteral administration has been ineffective in the treatment of chronic osteomyelitis. After trying it without success in a few cases, we abandoned it. When it is used in conjunction with systemic therapy, however, local administration of penicillin may offer certain advantages.

TABLE 3.—*Total Dose of Penicillin Administered During the First Course of Treatment*

No. of Units *	No. of Cases	Per Cent
500,000.....	9	1
1,000,000.....	6	60
1,500,000.....	9	1
2,000,000.....	2	1
2,500,000.....	4	1
3,000,000.....	5	1
3,500,000.....	2	40
4,500,000.....	1	1
5,000,000.....	1	1
5,500,000.....	1	1

\* The dose has been computed to the nearest 500,000 units.

Owing to variations in the availability of penicillin throughout the period of study, the dosage of penicillin and the duration of treatment varied

considerably. During the early months small doses and short courses of treatment were given. Later, as the supply of penicillin became more plentiful, the dose was increased and the period of treatment was lengthened.

In this study the total dose of penicillin ranged from 400,000 to 5,500,000 units. In table 3 the cases are grouped according to the total dose administered. In 24 cases (60 per cent) the total dose was between 400,000 and 1,500,000 units, while in the other 16 cases (40 per cent) it was 2,000,000 units or more.

The duration of treatment varied from two to fifty-six days. In table 4 the cases are grouped according to the number of days that systemic penicillin therapy was given. In 30 cases (75 per cent) the duration of treatment was between fourteen and thirty-two days.

Penicillin was applied locally in conjunction with systemic treatment in 16 cases (table 1). The total dose administered locally varied from

TABLE 4.—*Duration of Penicillin Therapy During the First Course of Treatment*

Days	No. of Cases	Per Cent	Days	No. of Cases	Per Cent
2	1	15	22	2	37.5
6	3		24	5	
8	1		26	3	
12	1		28	4	
			32	1	
14	2	37.5	36	1	10
16	6		42	1	
18	2		54	1	
20	5		56	1	

3,000 to 400,000 units. The period of local administration ranged from three to fifteen days.

The original object of this study was to observe the effect of penicillin alone in the management of chronic osteomyelitis. Early it was realized that when sequestrums were present or when there was evidence of an undrained intramedullary abscess surgical intervention was advisable. Operation was performed concomitantly with the administration of penicillin in 12 cases. In 8 cases (cases 29, 30, 33, 34, 35, 37, 38 and 40), sequestrectomy was performed; in 3 (cases 31, 32 and 36), a window was made in the cortex and an intramedullary abscess drained, and in 1 case (case 39), in which technical difficulties made it impossible to remove a sequestrum, partial excision of the sinus tract only was carried out. In the cases in which operation was performed, penicillin was administered systemically for several days before operation, in order to reduce acute inflammation and to diminish the possibility of a spread of the infection following operation.

Before operation special attention was directed toward obtaining roentgenograms which would locate accurately osteomyelitic cavities and sequestrums. To accomplish this purpose it was necessary to have films taken from several angles. Roentgenograms taken immediately after the injection of iodized poppyseed oil into the sinus tracts proved to be of great value in determining the extent of sinus tracts and the relation of

for only a short distance actually led, by a tortuous route, to a cavity or a sequestrum which was a considerable distance from the opening of the sinus. So helpful, in fact, was this procedure in demonstrating accurately the focus of active infection that it is now being used in every case in which surgical intervention is contemplated.

Additional information regarding the relation of sinus tracts was obtained by injecting the tracts with methylthionine chloride (methylene blue) at the beginning of an operation. Occasionally this led to the discovery of sequestra which were too small to be recognized on roentgenograms.

In carrying out surgical procedures the following considerations were kept in mind. Since sequestrums have no blood supply, penicillin from the blood stream reaches bacteria present in sequestrums with difficulty. Osteomyelitic cavities within sclerosed bone, although partially vascularized, present a similar problem, since penicillin will not diffuse into such areas from the blood stream in adequate concentration. Local circulation is also impaired in soft tissue scars and sinus tracts. Bacteria encysted in soft tissue are protected from penicillin and may serve as a focus for a recrudescence of the infection at a later date. Furthermore, scar tissue may harbor sequestrums which are too small to show in roentgenograms of too light a density to show in roentgenograms.

As a result of these considerations, the following general program was observed for all patients who were subjected to surgical treatment. Sinus tracts and all scar and granulation tissue were excised as far as it was possible and attempted to do so. All osteomyelitic cavities that were suspected of being the site of active infection were exposed and thoroughly curetted. A window of sufficient size to permit thorough curettage was made in the bone, but the cavities were not saucerized.

The decision not to saucerize cavities was made after we had observed healing taking place in several patients with cavities following the use of penicillin alone (fig. 3). This observation encouraged us to believe that if the infection could be eradicated by penicillin and cavities made to fill with sterile granulation tissue, no obstacle to satisfactory and lasting healing would exist. The crucial point appeared to be whether cavities could be sterilized. It was recognized that if reliance were placed entirely on systemic administration of penicillin it frequently might not be possible to achieve sterilization. On the other hand, it was felt that if systemic administration were supplemented by local instillation of con-

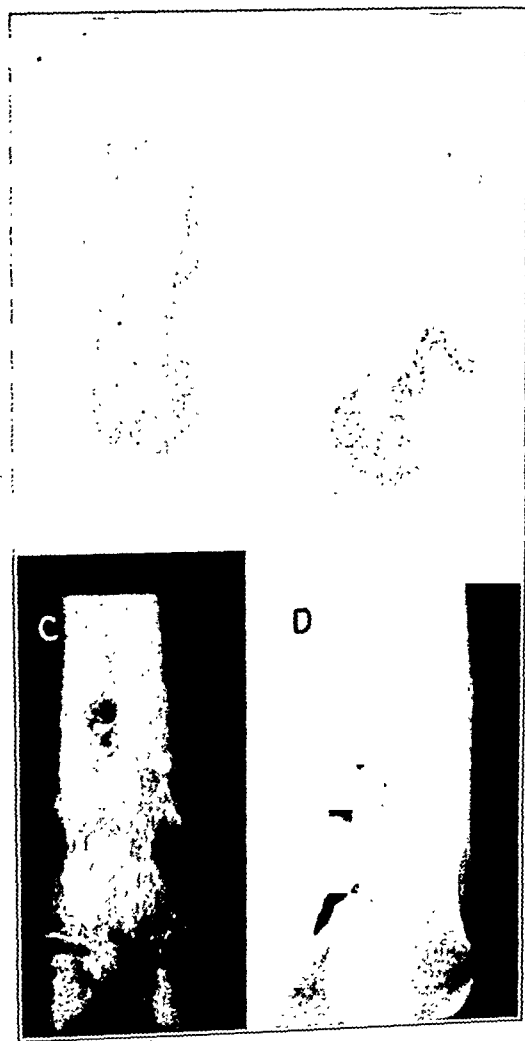


Fig. 1 (case 39).—A, anteroposterior view of the right femur; B, lateral view; C and D, same views after instillation of iodized poppyseed oil into the sinus tract, which led to the osteomyelitic cavity containing a sequestrum and also to the sequestrum in the popliteal space. During the first course of penicillin therapy the sinus tract was only partially excised. Relapse occurred after one month. With the second course of penicillin therapy both sequestrums were removed, and the incision has remained healed for two months.

osteomyelitic cavities or sequestrums to these tracts (figs. 1 and 2). Often such films demonstrated that a sinus tract that could be probed

centrated solutions of penicillin, as will be described subsequently, the chances of sterilizing cavities would be extraordinarily good. Finally, we were anxious to determine whether it was possible to avoid the destruction of healthy bone, a procedure that inevitably increases the amount of repair of bone necessary for final healing.

possible to maintain a constant high concentration of penicillin at the site where it was most needed. In a few cases needles used for inducing continuous spinal anesthesia were employed instead of the rubber catheters. They proved to be much more awkward to manipulate and so were not used after a few trials.

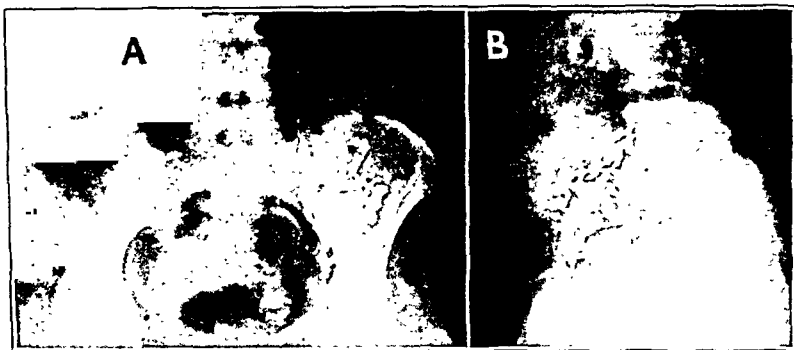


Fig. 2 (case 6).—Anteroposterior view (A) and lateral view (B) of the pelvis after instillation of iodized poppyseed oil into the sinus tract. The patient had had osteomyelitis of the sacrum for three years. Because of the extent and location of the abscess, surgical treatment was not attempted. After intramuscular administration of 70,000 units of penicillin daily for twenty days and local instillation of 4,000 units daily for fifteen days, the sinus healed and has remained healed for sixteen months.

When the window had been made sufficiently large, the edges of the bone were made smooth and a careful attempt was made to remove all bone sand and chips resulting from the surgical procedure. After the exposure had been completed, the cavity curetted, scar and granulation tissue excised and sequestrums removed, the wound was gently irrigated with copious quantities of warm isotonic solution of sodium chloride. A suction apparatus was employed to remove the fluid and whatever fine particles of bone sand remained. One or more fine soft rubber catheters were then implanted within the bone cavity and sutured to the skin. The wound was closed in anatomic layers, with the use of as little surgical gut suture material as possible below the skin. The cutaneous edges were accurately apposed with fine steel wire interrupted sutures. Steel wire was used because it produces less reaction in the presence of infection than does either cotton or silk. No drains were inserted.

A large, bulky, soft sterile dressing was applied. The ends of the catheters were led out through the main dressing and were covered with a superficial sterile dressing. At the completion of the dressing 1 to 5 cc. of penicillin solution was injected into the catheter, the free end of which was then clamped.

This surgical procedure made the operative area a relatively closed system, with penicillin reaching it both from the blood stream and through the catheters. In this fashion it was

Additional doses of penicillin were given through the catheters every twelve hours. Five thousand units per cubic centimeter of solution

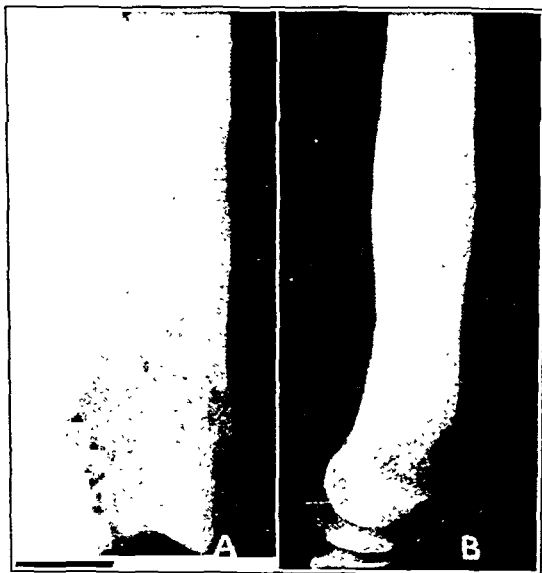


Fig. 3 (case 3).—Anteroposterior view (A) and lateral view (B) of the left femur, showing an osteomyelitic cavity. No surgical operation was performed. The sinus healed after 75,000 units of penicillin had been administered intramuscularly for sixteen days. The patient has remained well for fourteen months.

was used except in a few cases in which a concentration of 1,000 units was employed. The volume of penicillin solution given by catheter

was gradually reduced, so that by the fifth post-operative day the patient was not receiving more than 1 cc. every twelve hours through any one catheter.

The catheters were generally removed between the seventh and the fourteenth postoperative day, most commonly on the tenth day. The steel wire cutaneous sutures were removed when the incision was well healed, ordinarily between ten and fourteen days after the operation.

Most patients with involvement of a lower extremity were kept at complete rest in bed for one month after the sinus was healed. Patients in whom an upper extremity was involved were usually allowed to get up three to ten days after the operation. These patients as a rule were required to use a sling for one month after the incision was healed.

In this series splinting was used in only 1 case (case 39). In this case a long circular plaster splint was applied after a complete popliteal dissection through massive dense scar tissue had been performed.

No other form of specific chemotherapy was employed. No special diet was given. Patients who were anemic were given 0.2 Gm. of ferrous sulfate four times a day. Three patients received transfusions of whole blood. One patient, who was in shock, received 1,000 cc. of plasma.

*Second Course of Treatment.*—A second course of penicillin therapy was given to 9 patients who relapsed (table 1). It is of interest that 3 patients had staphylococcal bacteremia at the time of the relapse. The total dose administered during the second course of treatment to 7 of the patients was more than twice that administered during the first course.

Operation was performed in 3 of the 9 cases. In 1 of these (case 39) a sinus tract had been partially excised during the first course of therapy. During the second course sequestrectomy was performed. In the other 2 cases (cases 27 and 28) no surgical operation had been done during the first course of treatment. With the second course of penicillin therapy sequestrectomy was performed in case 27 and simple excision of a sinus tract was carried out in case 28. These last 2 cases brought to 14 (35 per cent) the number in which operative procedures had been performed in conjunction with the administration of penicillin.

#### RESULTS

There was 1 fatality in this series of 40 cases (case 15). The patient was a 24 year old man who had had chronic osteomyelitis of the femur

for sixteen years. He had been in good health for several years until one week before admission to the hospital, when there was a sudden onset of high fever, together with the appearance of a new abscess at the site of an old healed sinus. On admission to the hospital the patient was semicomatose and in shock. The blood culture was positive for *Staph. aureus*. Despite continuous intravenous infusion of penicillin at a rate of 15,000 units per hour together with administration of plasma and oxygen, he died less than forty-eight hours. Postmortem examination revealed extensive active osteomyelitis of the upper end of the femur and innumerable septic infarcts of the lungs. This case illustrates well the fact that even massive doses of penicillin will not save a moribund patient.

Except for the patient in this case, all the patients who had constitutional manifestations of an active infection were relieved of their symptoms within a short time after the beginning of penicillin therapy. Almost invariably the appetite improved within seventy-two hours. By the end of the first week there was distinct abatement in pain, fever and malaise. After two weeks these symptoms had disappeared. Several patients who had admitted no constitutional symptoms on entry to the hospital stated that they noticed an increased sense of well-being after seven to ten days of penicillin therapy.

In anemic patients a steady regeneration of hemoglobin was observed, and for patients who had lost weight a gain of 15 to 25 pounds (6.8 to 11.3 Kg.) in the first one or two months after treatment was the usual event.

The effect on the local lesions was equally striking. Usually within five to seven days the signs of acute inflammation disappeared and the discharge was reduced to one quarter or less of the amount that had been present at the beginning of treatment.

After the first week improvement of the local lesions was often slow. Drainage frequently persisted for some time after penicillin therapy was discontinued, but in 27 of the 35 cases in which the lesions were draining on the patient's entry to the hospital, closure of the sinuses occurred in one to eight weeks (average, four weeks) after the beginning of treatment.

The effect on cultures of the blood and of material from the local lesions should be noted. Except in the fatal case, sterile blood cultures were obtained in one to five days in the 4 cases of bacteremia. Cultures of material from the local lesions usually showed a striking decrease in the

number of organisms within three to four days. In 25 cases it became impossible after penicillin had been administered to recover any organisms on repeated culture of material from the local lesions. Material for the cultures was obtained with a fine cotton swab, which was introduced as deeply as possible into a local lesion. The swab was then streaked on a blood agar plate and also inoculated in 5 cc. of veal infusion broth. The blood agar plate was incubated for twenty-four hours and then discarded if no growth had appeared. The broth culture was incubated for seventy-two hours and was then subcultured on blood agar. If the broth remained clear and if no growth was obtained on subculture, the culture was recorded as negative.

The time required to obtain sterile cultures after the beginning of treatment varied from

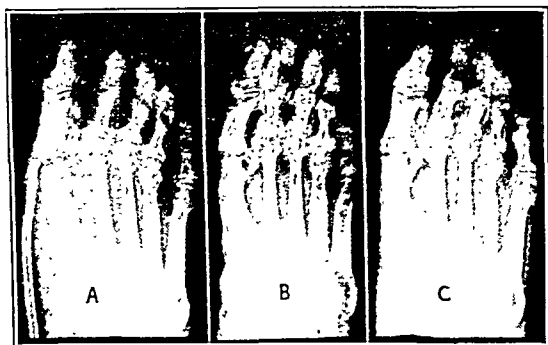


Fig. 4 (case 34).—Anteroposterior views of the right foot, illustrating the rapidity of repair of bone in a 74 year old woman following sequestrectomy and systemic and local administration of penicillin. A, nine days postoperatively; B, two months postoperatively; C, three months postoperatively. This patient also had diabetes mellitus.

three to twenty-one days and averaged eleven days. In most cases sinuses which had once become sterile remained sterile after administration of penicillin was discontinued, until healing took place one or more weeks later. In 4 cases (cases 11, 27, 33 and 39), although the sinuses healed cultures made just before the sinuses closed were still positive for *Staph. aureus*. No correlation was observed between the results of therapy and the variations in the initial susceptibility of the strains of *Staph. aureus* in the 32 cases in which this factor was studied.

In 19 cases it was possible to test the susceptibility to penicillin of staphylococci cultured from the local lesions after the patient had received treatment with penicillin for one week or longer. Fourteen strains showed no change in sensitivity to penicillin. In 5 cases (cases 11,

14, 22, 23 and 40) the organisms acquired a definite resistance to the action of penicillin. Before treatment the strains in these cases had been completely inhibited by concentrations of 0.08 Oxford unit in 1 cc. of medium or less. The strains tested after one week or more of treatment required concentrations of 5.7 Oxford units or more in 1 cc. of medium to produce complete inhibition. In 2 of these cases (cases 11 and 14) the sinuses eventually closed. In the other 3 cases they continued to drain. In 2 of these cases (cases 22 and 23) cultures made a year after the completion of penicillin treatment showed that the organisms were still resistant to penicillin.

Changes observed in the roentgenograms after penicillin treatment deserve special comment. The changes were most striking in those cases in which surgical procedures were combined with the use of penicillin. In such cases it was not uncommon to observe over a period of months roentgenographic evidence of rapid healing, with marked decrease in the size of cavities and improvement in the texture of the adjacent bone (figs. 4, 5 and 6). In patients who were treated with penicillin alone and in whom comparative roentgenograms indicated that there had been progressive destruction of bone in the period immediately preceding treatment, evidence of rapid repair was seen.

Evidence of repair and healing in patients who were not operated on and in whom the osteomyelitis had been relatively static for some time was less striking, but in those patients for whom it was possible to take serial roentgenograms over a period of six to twelve months definite signs of improvement were observed in almost every case.

TABLE 5.—Summary of the Results of the First Course of Treatment

Result	No. of Cases
Arrested infection.....	32
Relapsed.....	15
Improved.....	2
Not improved.....	5
Died.....	1
Total.....	40

In table 5 the results of the first course of treatment are summarized. We have classified the condition as arrested in those cases in which all local and constitutional symptoms of infection disappeared and in which all sinuses ceased to



drain and became epithelized. Temporary arrest of the infection was obtained in 32 (80 per cent) cases.

In 2 cases the result was classified as improvement, because although the sinuses never completely healed there was in each instance a strik-

treatment showed complete disappearance of the dye from the serum after one hour. After administration of 1,600,000 units of penicillin over twenty-three days, the retroperitoneal abscess healed, although the sinuses in the thigh continued to drain. The patient's general condition



Fig. 5 (case 35).—Anteroposterior and lateral views of the left humerus, illustrating the rapidity of repair of bone in a 14 year old boy following sequestrectomy and systemic and local administration of penicillin. *A*, before operation; *B*, three weeks postoperatively; *C*, five weeks postoperatively; *D*, ten weeks postoperatively; *E*, fifteen weeks postoperatively.

ing improvement in both the general condition of the patient and the state of the local lesions.

One of these cases (case 20) deserves special mention. The patient had had chronic osteomyelitis of the right femur and an extensive retroperitoneal abscess (fig. 7) for six years. Physical examination performed on his entry to the hospital revealed the liver to be palpable 8 cm. and the spleen 6 cm. below the costal margin. A congo red test performed prior to

was greatly improved, and he was discharged from the hospital. There was no change in the size of the liver or the spleen.

During the next four months the patient gained 50 pounds (22.7 Kg.). At the end of this time the retroperitoneal abscess opened spontaneously. The patient continued to feel well, however, for the next three months, after which drainage from the abscess suddenly ceased. Three weeks later he had a chill, and the temperature rose

to 103 F. He was then readmitted to the hospital. A blood culture made when he reentered the hospital was positive for *Staph. aureus*. A few hours later the retroperitoneal abscess drained spontaneously. The liver and the spleen had not changed in size since the previous admission. During the next fifty-five days the patient received a total of 6,700,000 units of penicillin. After one week of treatment the temperature became normal. The retroperitoneal abscess healed after five weeks of treatment, as did a sinus on the medial aspect of the right thigh. A sinus on the lateral aspect of the thigh was

this patient as the result of the chronic infection and that when the infection was controlled with penicillin there was gradual resorption of the amyloid deposits in the tissues.

In 5 cases there was no improvement, and in 1 death occurred. Failure to improve in 4 cases (cases 14, 22, 23 and 40) resulted from the fact that the patients' organisms became fast to penicillin. In the other case (case 13) there were an ununited fracture of the tibia and an extensive area of exposed and denuded bone in the floor of the sinus. Surgical treatment was refused in this case.

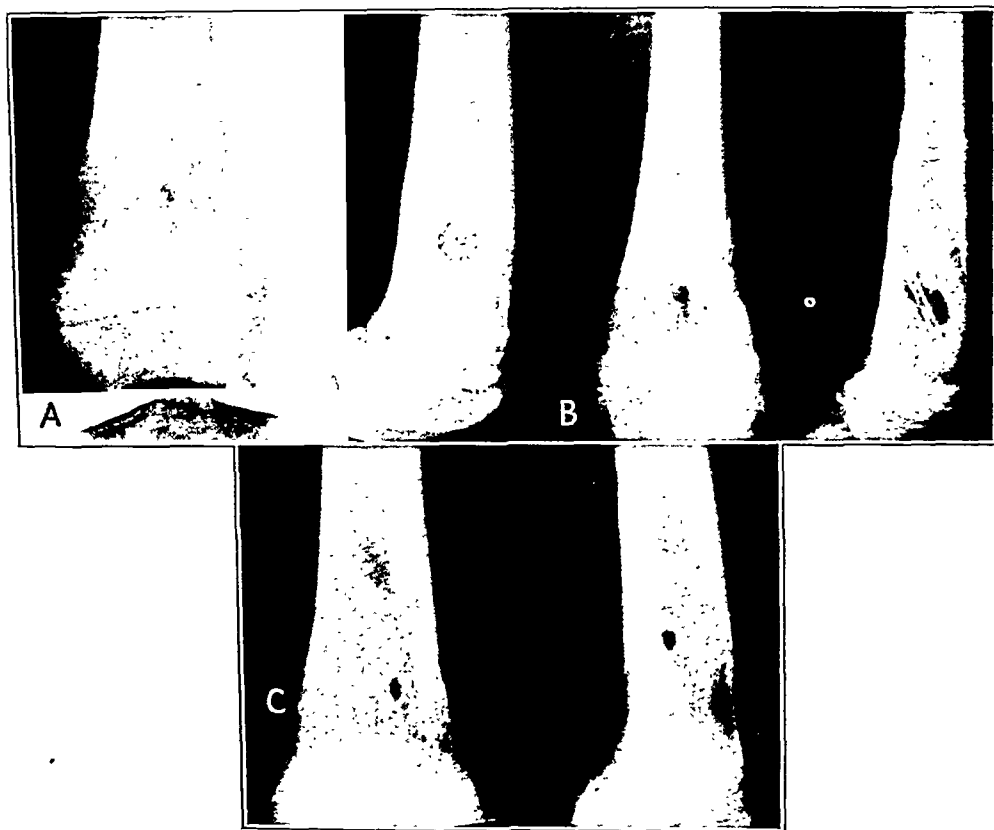


Fig. 6 (case 30).—Anteroposterior and lateral views of the femur, illustrating the extent of repair of bone and the reduction in size of an osteomyelitic cavity thirteen months after sequestrectomy and treatment with penicillin. *A*, before operation; *B*, five days postoperatively; *C*, thirteen months postoperatively.

reduced to the size of a pinpoint but continued to drain despite treatment for another three weeks. A congo red test performed after the patient had been under treatment for six weeks showed that 43 per cent of the dye remained in the serum one hour after injection.

After the patient's discharge from the hospital, he remained well. There was a gradual diminution in the size of the liver and spleen, until eight months after the beginning of the last course of treatment neither organ could be felt.

From the foregoing evidence it seems reasonable to conclude that amyloidosis developed in

Of the 32 cases in which arrest of the infection was obtained relapses occurred in 15 (47 per cent). Cultures made after the reappearance of drainage were positive for *Staph. aureus* in each case. The relapses occurred at intervals of one to fifteen months (average, four and nine-tenths months). In the 17 in which no relapses occurred after one course of treatment, the follow-up period ranged from three to twenty-one months (average, nine and six-tenths months). In 7 of these the patients have remained well for more than a year. Of the 15 cases in which relapses occurred the infection in 4 healed spontaneously

within one to two weeks after the relapse and has remained healed for from four to fourteen months.

In 8 cases, in addition to case 20, a second course of treatment was given, and in each case arrest of the disease was again achieved. In 6 the patients have remained well for an average



Fig. 7 (case 20).—Anteroposterior view of the pelvis after instillation of iodized poppyseed oil, demonstrating the extent of the retroperitoneal abscess.

of nine months, in 1 a relapse occurred at four months and treatment was given again and in 1 a relapse occurred at twelve months but drainage spontaneously ceased within three weeks.

TABLE 6.—Status of the Patients at the Time of Writing in the Entire Series of Forty Cases \*

Status	No. of Cases
Infection arrested; no relapse.....	23 †
Spontaneous arrest after relapse.....	5
Relapse; lesion now draining.....	4
Improved.....	2
Not improved.....	5
Died.....	1
Total.....	40

\* One course of penicillin therapy was given in 31 cases and two courses in 9.

† These cases include 6 in which relapses occurred after the first course but in which the infection was arrested after the second course of penicillin therapy.

The status of the patients at the time of writing in the entire series of 40 cases is summarized in table 6. In 28 cases (70 per cent) there were no draining sinuses or symptoms of active infection at this time.

#### TOXIC REACTIONS

One of the most remarkable properties of penicillin has been its lack of significant toxicity. In this series no serious toxic reactions were observed. Minor untoward reactions were observed in 8 cases. Thrombophlebitis developed in 3 cases during constant intravenous infusion of penicillin. In 1 case diarrhea developed. Chills and fever, which were apparently caused by a solution of penicillin that had become contaminated or had deteriorated, occurred in 1. When a fresh solution of the same lot of penicillin was used, no untoward reaction occurred. Urticaria developed in 3 cases. In case 27 urticaria developed on the fourteenth day of the first course of treatment. The urticaria was accompanied by transient fever, sore throat, arthralgia and generalized lymphadenopathy. Administration of penicillin was omitted for nine days, by the end of which time the urticaria had almost entirely subsided. Endermic and conjunctival tests with penicillin showed no reaction, and treatment was resumed for another eleven days. The urticaria did not recur. When the patient received a second course of penicillin treatment eight months later, penicillin from a different manufacturer was used. On the eighth day of treatment urticaria appeared, but without the other signs and symptoms which had accompanied the previous attack. Treatment was continued, and the urticaria disappeared after four days. In case 27 mild urticaria was experienced from the thirteenth through the fifteenth day of treatment. The reaction disappeared, although treatment was continued for another fourteen days. In case 29 there was mild urticaria for three days, beginning eight days after the completion of a twenty day course of treatment. In none of these cases was there a history of any preceding allergic phenomena.

#### COMMENT

From the experience provided by these 40 cases it can be said that penicillin, by inhibiting the growth and multiplication of bacteria, will arrest the infection in a high percentage of cases of chronic osteomyelitis and thus allow healing of both bone and soft tissue to take place. In only a small percentage of cases does the use of penicillin fail to produce significant improvement.

The specific reasons for failure in those cases in which no improvement was observed have been presented in the preceding section. The chief cause of failure was the development of resistance to penicillin in the infecting organism. The patients whose organisms became resistant were not treated differently from those whose

organisms did not become resistant, and it is not clear how this untoward event can be prevented. It does not appear to be a problem of dosage, since in 3 of the 5 cases in which resistance to penicillin appeared the dose was well above the average for the group. The only measure that we have devised to meet this situation is definitive surgical treatment early, at a time when the organism is still sensitive to penicillin.

While immediate improvement with the disappearance of all signs of infection was observed in 80 per cent of the patients treated, a relatively high incidence of relapses (47 per cent) was encountered. Positive cultures obtained at the time of the relapse indicate that in these instances, at least, penicillin merely suppressed the infection temporarily and did not eradicate it. Of course at this time it is impossible to conclude that viable bacteria may not still be present in those patients who have remained well. A long period of observation will be necessary before it can be determined whether penicillin can permanently eradicate the infection in any case of chronic osteomyelitis.

An analysis of the 15 cases in which relapses occurred should be helpful in disclosing some of the conditions that may lead to early reappearance of the signs of active infection. It is striking that in 9 of the cases demonstrable sequestrums had not been removed. In several of these cases, the reappearance of drainage was associated with the spontaneous extrusion of sequestrums. Relapse in 1 case was definitely related to trauma. In 5 cases no definite cause could be found for the relapse. In all these cases, however, there was massive fibrosis of the soft tissues.

The significance of sequestrums in predisposing to relapses is evident. It is made even more conspicuous by the observation that of the 17 cases in which the patients remained well, in 10 there were no sequestrums and in 6 sequestrums were removed at the time penicillin was administered. In only 1 case (case 1) in which a sequestrum was not removed has the patient remained well (fig. 8).

Including both the first and the second course of treatment, operation was performed in 14 cases. A comparison of the results obtained in the group in which penicillin alone was used with those obtained in the group in which both penicillin and surgical operation were employed is significant (table 7). In only 1 case of the latter group did the incision fail to heal. The patient (case 40) whose organisms became re-

sistant to penicillin was diabetic. In only 2 cases did a relapse occur. In both cases all sequestrums were not removed at operation. In 1 of these cases (case 38), the sinus closed spontaneously after the sequestrum was extruded, while in the other (case 39) the sinus closed after the sequestrum was removed surgically.

Among the 26 cases in which no surgical procedure was performed, death occurred in 1, there was no improvement in 4, improvement was obtained in 2 but the infection persisted and the infection was arrested in 19. In 11 of the 19 relapses occurred. It is clear, from a comparison of the results in these two groups, that if ade-



Fig. 8 (case 1).—Anteroposterior view of the right femur, showing a sequestrum. This was the only case in which relapse did not occur when a demonstrable sequestrum was not removed.

quate surgical treatment can be carried out in those cases in which it is indicated at the same time that penicillin is administered the chances for securing an arrest of the infection are greatly increased.

Primary closure of all operative incisions has been extremely satisfactory. In no case did an untoward reaction result from primary closure. To the time of writing no relapse or failure to improve has occurred as the result of the decision not to saucerize cavities. On the contrary we

have been gratified with the rapidity with which repair of bone has taken place, and the size of the cavities has decreased. Complete saucerization of these cavities would have increased greatly the time necessary for repair of bone.

TABLE 7.—A Comparison of the Results Following Treatment with Penicillin Only and Those Following Treatment with Penicillin and Surgical Operation

	No. of Cases
Treatment with penicillin only.....	26
Infection arrested (11 relapsed).....	19
Improved.....	2
Not improved.....	4
Died.....	1
Treatment with penicillin and surgical operation.....	14
Infection arrested (2 relapsed).....	13
Not improved.....	1
Total.....	40

With chronic osteomyelitis more than one species of bacteria are frequently found when material from the lesions is cultured. In the present series a mixed culture was encountered in 9 cases. In 6 cases one of the secondary organisms was a beta hemolytic streptococcus, an organism which is even more susceptible to penicillin than are the staphylococci. In every case the streptococci disappeared from the cultures before the staphylococci did.

In 6 cases gram-negative bacilli were found on culture. In 3 of these cases (cases 9, 19 and 33), the gram-negative organisms spontaneously disappeared from the cultures after a few days and the sinuses eventually healed. In the other 3 cases the gram-negative organisms persisted. In 1 case (case 25), the presence of gram-negative bacteria may have been responsible for the failure of the sinus to heal. Staphylococci disappeared from cultures while administration of penicillin was continued but reappeared after completion of treatment. In this case, however, striking improvement occurred and a large open wound, 7 by 5 by 3 cm., over the sacrum was converted to a pinpoint sinus. In the other 2 cases (cases 22 and 23), failure to improve resulted from the fact that the infecting staphylococci became resistant to penicillin.

In figure 9 the results of the first course of treatment are plotted against the total dose, computed to the nearest 500,000 units. Good results were obtained with total doses ranging from 500,000 to 3,000,000 units or more. The apparent correlation between the increased dose and the successful results must be questioned

when consideration is given to some of the other variables that were present. The group of patients who received the larger dose are those who have been treated most recently and have been followed for the shortest period. In addition, 8 of the 10 patients in this group had operative procedures in conjunction with the administration of penicillin. On only 4 of the 30 patients who received less than 3,000,000 units were surgical procedures performed.

It is our belief, from observing the cases and taking into account the many variables that are present, that a dosage of 15,000 units given intramuscularly every three hours for two to four weeks is effective in most cases. The dosage should be controlled, however, by the response of the lesions and the results of cultures. If there has been no decrease in the amount of drainage and no significant reduction in the number of organisms obtained on culture of material from the local lesions after four to six days of treatment, the advisability of increasing the dose to 25,000 units every three hours should be considered. In view of the lack of toxic reactions following the use of penicillin, doses larger than those recommended here may well prove to be desirable when penicillin becomes available in greater quantities.

In general, patients not requiring surgical operation are treated with penicillin until sterile material has been obtained from the local lesions

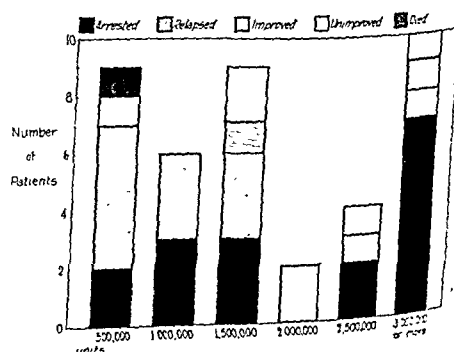


Fig. 9.—Chart correlating the results of the first course of treatment and the total dose of penicillin administered.

for five to ten days. For patients requiring operation, administration of penicillin for four to eight days preoperatively and for ten to twenty days postoperatively is adequate in most instances.

Continuation of treatment until the sinuses are completely healed is apparently not necessary if the material has been sterile for several days. In most of our cases open sinuses persist!

for one or more weeks after completion of treatment and then healed satisfactorily.

Roentgenograms have not been helpful in determining how long to continue treatment. Even in those patients whose roentgenograms show the most rapid improvement, changes appear too slowly to be of any value in guiding treatment.

#### SUMMARY AND CONCLUSIONS

Penicillin therapy was used in 40 cases of chronic osteomyelitis. Twenty-five of the patients

have been observed for a year or longer after treatment.

Operative procedures were combined with the use of penicillin in 14 cases.

At the time of writing, in 28 cases (70 per cent) there are no draining sinuses or other symptoms or signs of active infection.

Primary closure following sequestrectomy or evacuation of an abscess of a bone is a safe and satisfactory procedure for patients who are receiving penicillin.

Miss Marjorie Jewell gave her technical assistance.

## PROGRESS IN ORTHOPEDIC SURGERY FOR 1943

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

(Continued from page 212)

### VII. CONDITIONS INVOLVING THE ELBOW, FOREARM, WRIST AND HAND

PREPARED BY WALTER P. BLOUNT, M.D., MILWAUKEE

*The Elbow Joint.*—A critical review of 51 wounds involving the elbow joint received in the third Libyan battle in the summer of 1942 is submitted by Buxton.<sup>225</sup> The routine treatment is described, and a statistical study has been prepared, largely from form questionnaires. There was no fracture in only 3 cases. There was great variety in the types of injury to the bone. A primary diagnosis of injury to 14 nerves in 12 patients was made. Paralysis of 2 ulnar nerves was diagnosed later. Of these 16 lesions of nerves, 9 had healed in four months or less. Five had healed in less than seven months, and the end result in 2 was not known. The damage was caused largely by hemorrhage and edema. Many of the nerves recovered their function before the wounds had healed.

In all cases operation was performed more than eleven hours after injury. Suppurative arthritis developed in thirty-one joints. It is the writer's opinion that the suppuration was less and the results better when all loose fragments were removed. This was particularly true after removal of the olecranon, after which a secondary operation was seldom necessary. Primary excision of the joint is rarely indicated in gunshot wounds. In those wounds in which drainage was not adequate following the removal of the loose pieces of bone, posterior drainage was instituted by making 2 wounds, 1 on each side of the olecranon. Fixation was accomplished by plaster of paris, with the elbow at a right angle.

The lessons to be learned from the study are listed:

1. Exercise or actual use of the shoulder and finger joints should be started at once.

2. Active motion of the elbow should not be started until the arthritis is quiescent. Nothing is gained by passive motion.

3. In some elbows with 30 degrees of movement after eight or ten weeks the condition proceeded to a fibrous ankylosis.

225. Buxton, S. J. D.: Gunshot Wounds of the Elbow Joint, *Lancet* 2:663-665 (Nov. 27) 1943.

4. Some elbows with loss of the olecranon and severe infection regained up to 70 degrees of flexion-extension mobility and half of supination-pronation movement.

5. Recurrent osteomyelitis and formation of sequestrums are not common sequels of elbow wounds when the primary operation is planned.

6. In this series recovery from injury to peripheral nerves without operation was frequent.

A study of the end results was impossible. The anticipated ultimate conditions are listed as follows:

	No. of Cases
Ankylosis .....	17
Flail elbow .....	4
Movement greater than 30 degrees....	22
Movement less than 30 degrees.....	5
Amputation .....	2

Two amputations were performed, because of the extent of the wound. None was required because of suppuration. One death was recorded of a man with many complicating wounds.

For the reinforcement of flail elbow, Brunner<sup>226</sup> suggests a technic similar to that employed for the knee. It is better to use muscle-activated strips of tendon than free transplants of fascia. The writer suggests stripping up the medial half of the triceps tendon, which is then passed under the elevated ulnar nerve and the flexor carpi ulnaris and the flexor digitorum sublimis muscle, where it is sutured to the periosteum of the ulna. After three weeks of immobilization in a plaster splint, exercises are started, without local heat or massage. Nine cases are cited, and only diagrammatic drawings accompany the article.

In a girl of 15 years recurrent dislocation of the ulna at the elbow had been present since the age of 3. Recurrence was prevented by Gross.

226. Brunner, K.: Zur operativen Versorgung der ulnaren Bandschadens am Ellenbogengelenk, *Zentralblatt f. Chir.* 69:268-271 (Feb. 14) 1942.

man<sup>227</sup> by driving a bone peg into the coronoid process. The method was similar to that described by Milch. A year after operation there had been no recurrence. Extension was normal, and flexion was somewhat limited. With complete flexion the patient was conscious of the block.

Nine cases of post-traumatic ossifying peri-arthritis at the elbow are reported by Marottoli and Didier.<sup>228</sup> For the reduction of dislocations complete anesthesia is necessary to afford muscular relaxation. The elbow is fixated for three or four weeks, until there have been healing and resorption of the hematoma. To prevent the deposit of bone the writers emphasize adequate immobilization and avoidance of massage and passive movement. Treatment of existing deposits by immobilization is emphasized. This was sufficient in 2 cases. Roentgen therapy was used in the others. Surgical intervention was necessary in only 1 case, in which the calcified mass was huge. In this case roentgen therapy was used before and after operation. The cases are reported in detail.

Painful paralysis of the arm in small children is described by Feer,<sup>229</sup> in a pediatric journal, as a clinical entity. He reports 39 subluxations of the radial head in 22 children with similar symptoms. Their ages varied from 5 months to 4 years, and the histories were similar. A child was walking holding the hand of the mother. The child fell, and the mother drew the child quickly upward. Immediate pain appeared in the affected arm. The child let the arm hang and protected it carefully. Motion at the elbow joint was impossible. The hand was in pronation. The child was brought to the doctor, who manipulated the forearm into supination. There was a snap, and function was immediately restored. The writer does not use fixation.

Feer notes a high incidence of recurrences, occurring as late as three years and seven months after the initial subluxation. There was no recurrence after five years, and no new dislocation occurred after the age of 5. Relaxation of the ligaments was given as a predisposing cause. Many of the children had rickets. The diagnosis is confusing only if there is a coincident fever. Fracture of the clavicle is mentioned in the differential diagnosis.

[ED. NOTE.—In his historical discussion the writer confuses "pulled shoulder" with the lesion under discussion. It may be that some of his cases were instances of strained shoulder rather than of true subluxation of the radial head. The two entities are distinct. They should be better known to all orthopedic surgeons. The cause is the same. When the capsule of the shoulder joint is strained, the arm hangs limp and simulates paralysis. The recovery is spontaneous in a few days. A sling is all that is indicated.]

In subluxation of the radial head, the arm is held stiffly and somewhat forward, with the hand pronated. The child will move the shoulder and elevate the extremity forward but will not allow any one to touch the hand or forearm. After a word of warning the forearm may be supinated with a quick twist. There is an audible and palpable snap. Pain is relieved and function restored. If there has been delay in reduction, the elbow will be extremely sore. It is well to use a retentive bandage for several days or even longer. Perhaps some of the recurrences which the writer mentions might have been eliminated had he used a retentive dressing or some form of fixation.]

*The Wrist.*—Gollasch<sup>230</sup> reports a case of osteochondritis dissecans of the wrist in a patient who had had a similar lesion of the elbow on the opposite side. In the course of the examination, crepitation of the wrist called attention to the lesion, although motion was normal. The patient complained of pain after prolonged use. A free body could be palpated just distal to the ulna on the dorsum of the wrist. The source of the free body was not determined.

McGoey<sup>231</sup> reports an injury of the wrist following an impact against the palm and along the axis of the forearm, which caused fracture and dislocation of a congenitally unseparated lunate and triangular bone. There was a fracture of the posterior surface of the anomalous bone, with a dislocation of the carpus posteriorly. Reduction was easily accomplished by simple traction, with the patient under anesthesia. After ten weeks of immobilization the patient resumed use of the wrist. There was a 5 degree limitation of palmar flexion; otherwise recovery was complete at thirteen weeks.

*The Hand.*—A classification of kinetic disabilities of the hand is developed by Burman.<sup>232</sup>

230. Gollasch, W.: Osteochondritis dissecans des Handgelenks, Röntgenpraxis 14:468-469 (Dec.) 1942.

231. McGoey, P. F.: Fracture-Dislocation of a Fused Triangular and Lunate (Congenital), J. Bone & Joint Surg. 25:928-929 (Oct.) 1943.

232. Burman, M.: Kinetic Disabilities of the Hand and Their Classification, Am. J. Surg. 61:167-214 (Aug.) 1943.

227. Gosman, J. A.: Recurrent Dislocation of the Ulna at the Elbow, J. Bone & Joint Surg. 25:448-449 (April) 1943.

228. Marottoli, O. R., and Didier, A. E.: Las periartritis osificantes del codo, Bol. Soc. de cir. de Rosario 398-412 (Sept.) 1942.

229. Feer, W.: Die schmerzhaftes Armlähmung kleiner Kinder, Kinderärztl. Praxis 13:225-228 (Sept.) 1942.



These comprise mainly the spastic hand, the arthritic hand, the paralytic hand and the traumatized hand. Cases of paralysis contracture and muscular imbalance are included. The various disabilities are analyzed. Conservative and operative treatment is suggested. A detailed discussion with summaries of the cases and a bibliography is furnished.

After examining the roentgenograms of the hands of 1,000 normal infants and 290 abnormal ones, Brailsford<sup>233</sup> gains the impression that separate additional osseous nuclei may develop in the first and the second year of life and fuse before the osseous nuclei for the normal epiphyses appear. In certain dysostoses, other separate additional osseous nuclei develop soon after the diaphysial nuclei, remain without bony union until puberty and then unite with the diaphysis a year or so before the normal epiphyses fuse. He found supplementary epiphyses in only 8.5 per cent of the normal hands. He discusses the appearance of normal and of abnormal epiphyses in congenital deformities, hypothyroidism, craniocleidodysostosis, arachnodactyly, chondrodysplasia and achondroplasia.

Two new cases are reported by Slater and Rubinstein<sup>234</sup> of aplasia of interphalangeal joints associated with synostosis of the carpal and tarsal bones. The skin over the proximal two thirds of the involved fingers is smooth and shows no transverse cutaneous wrinkles. Each finger appears to be composed of two phalanges, an abnormally long proximal one and a small distal one. There is an unusual range of flexion in the terminal phalangeal joint, which serves in a measure to substitute for the lost motion. The hand cannot be closed into a fist, but the persons are little handicapped by their "straight-fingered" hands.

The condition is bilaterally and symmetrically present in the hands and feet. It is hereditary and behaves as a dominant mendelian unit. The rigidity of the fingers results from hypoplasia, rarely aplasia, of the affected joints. There are frequently other associated skeletal anomalies, particularly synostosis of the carpal and tarsal bones.

Pain at the tip of the right index finger called the attention of Staples<sup>235</sup> to an isolated osteo-

chondritis (osteochondrosis) of the osseous center of the distal phalanx in a 4 year old girl. There were redness, tenderness and swelling without effusion into the distal joint. Motion of the finger were normal. Roentgenograms showed a small, dense epiphysis of the distal phalanx. After two weeks of splinting the local symptoms disappeared. Roentgenograms taken at regular intervals showed improvement of the condition. In five months the epiphysis was entirely normal.

Vogl<sup>236</sup> reports the case of a snapping middle finger of an unusual type. The middle joint of the middle finger was suddenly hyperextended while the patient was pulling on a shoe. After this incident, the middle joint could be flexed only with the assistance of the other hand and then with a snap. Spontaneous attempts to flex the finger at the middle joint resulted in flexion at the distal joint and hyperextension of the middle joint. Roentgenograms disclosed a slight angulation of the middle phalanx of the middle finger with the apex volarward and slightly to the ulnar side. Osteotomy was performed through the base of the middle phalanx to correct the lateral deviation and to produce volar flexion at this joint. The writer says that the snapping stopped and that voluntary flexion was possible. Follow-up roentgenograms showed obvious deformity.

[ED. NOTE.—Post-traumatic hyperextension deformity of the middle joint of a finger probably deserves more attention than it has received. It is an extremely disabling condition. The writer's therapeutic approach seems warranted. He substitutes a new deformity for old, and the finger is still unsightly. At suggestion of Dr. Stirling Bunnell, one of (W. P. B.) attacked the same condition passing fascial grafts through drill holes in contiguous ends of the bone and thereby efficiently reenforced the palmar capsule. The resulting fingers appear normal, and function completely restored. This approach would seem more logical than an attack on the bone.]

The principle of intra-articular tenodesis applied by Slocum<sup>237</sup> to the stabilization of chronic dislocation of the first metacarpal on the multiangular bone. One-half inch (1 cm.) distal to the joint a hole was drilled obliquely through the metacarpal bone to the center of the joint to meet a similar hole originating from the dorsolateral aspect of the greater

233. Brailsford, J. F.: Variations in the Ossification of the Bones of the Hand, *J. Anat.* 77:170-175 (Jan.) 1943.

234. Slater, P., and Rubinstein, H.: Aplasia of Interphalangeal Joints Associated with Synostoses of Carpal and Tarsal Bones, *Quart. Bull., Sea View Hosp.* 7:429-443 (Oct.) 1942.

235. Staples, O. S.: Osteochondritis of the Epiphysis of the Terminal Phalanx of a Finger, *J. Bone & Joint Surg.* 25:917-920 (Oct.) 1943.

236. Vogl, A.: Schnellender Finger mit Infektion Ursache, *Ztschr. f. Orthop.* 73:139-140 (April) 1943.

237. Slocum, D. B.: Stabilization of the Articular Surface of the Greater Multiangular and the First Metacarpal, *J. Bone & Joint Surg.* 25:626-630 (July) 1943.

multangular bone. A piece of palmaris longus tendon was threaded through the drill hole, and with the thumb in moderate opposition it was sutured back on itself to form a loop. The joint was stable though freely movable. The remaining length of tendon was pliated across the back of the joint to form a new posterior capsular ligament. A cast was applied for three weeks. In the case reported a 22 year old Negro man obtained a good result after eight months. The patient returned to full duty as a cook in the United States Army.

When operative repair of a "baseball" finger (avulsion of the insertion of the extensor digitorum communis tendon) is necessary, Saypol<sup>238</sup> suggests an interesting addition to the technic. In order to anchor the tendon a needle is passed transversely through the base of the distal phalanx and a thread is drawn through. A transverse dorsal incision is sufficient to permit passage of tiny hooks around the needle on either side of the bone. As the needle is slowly passed through, the suture material is caught and brought out into the wound by the hook. The suture material is passed through the tendon and tied with the finger in hyperextension, hold-

ing the tendon or fragments of bone snugly in position. The finger is splinted by malleable metal, with hyperextension of the distal joint and slight flexion of the other joints.

A study of the extensor indicis proprius muscle is offered by three men from Northwestern University Medical School.<sup>239</sup> Two hundred and sixty-three extremities from 140 consecutive cadavers were studied. Forty-one of the 263 (15.6 per cent) showed marked differences in size, origin or insertion of the muscle or in all of these features. In no case was there a total absence. In 8 female cadavers the muscle was extremely small.

The muscle is found only in man, the gorilla and frequently the chimpanzee. In man it normally arises primarily from the ulna and secondarily from the interosseous membrane (75 per cent), the dorsal ulnar septum (58 per cent) or the extensor pollicis longus septum (58 per cent). In 3 cadavers the muscle was abnormal in origin only. Aside from variations in origin, supernumerary tendons were present in a total of 30 cadavers (11.4 per cent). Excellent drawings of anomalous tendons accompany the article.

238. Saypol, G. M.: Technic for the Repair of "Baseball" Finger, *Am. J. Surg.* 41:103-104 (July) 1943.

239. Cauldwell, E. W.; Anson, B. J., and Wright, R. R.: The Extensor Indicis Proprius Muscle, *Quart. Bull., Northwestern Univ. M. School* 17:267-279, 1943.

### VIII. CONDITIONS INVOLVING THE KNEE JOINT

PREPARED BY RALPH K. GHORMLEY, M.D., ROCHESTER, MINN.

*Embryology.*—McDermott<sup>240</sup> traced the development of the knee joint by means of serial sections from the third week of fetal life to birth, and the menisci were studied to the age of 2 years. A thorough review of the embryologic development of the knee joint is included in his article.

*Anatomy and Physiology.*—Brantigan and Voshell<sup>241</sup> made a detailed gross and microscopic study of the tibial collateral ligament and its environment. They say that this ligament is attached superiorly to the medial femoral epicondyle and inferiorly to two points on the tibia, one posterior, just below the articular cartilage, lateral to and above the insertion of the semimembranous tendon, and the second anterior to the medial tibial surface and 4.6 cm. below the articular surface. There are two divisions of the ligament: (1) anterior parallel fibers from the femur to the tibia and (2) posterior oblique

fibers. The anterior fibers have no capsular or meniscal attachments. The posterior fibers blend with the true capsule of the joint, which in turn blends with the posterior portion of the meniscus. The anterior portion is separated from the meniscus by true capsules and often by a true bursa lying in any portion of the ligament. [Ed. NOTE.—This article supplements others by these authors, which are of great importance for reviewing the anatomy of the knee.]

*Pathologic Conditions of the Knee Joint.*—Injuries and Dislocations: Anderson<sup>242</sup> reviews some of the reported cases of dislocation of the knee and adds 4 cases which he has observed. He briefly considers the complications which involve nerves, blood vessels and ligaments and also considers associated fractures. In 1 case open reduction was necessary, and in another case amputation had to be performed because of gangrene. Clarke<sup>243</sup> reports a case

240. McDermott, L. J.: Development of the Human Knee Joint, *Arch. Surg.* 46:705-719 (May) 1943.

241. Brantigan, O. C., and Voshell, A. F.: The Tibial Collateral Ligament: Its Function, Its Bursae, and Its Relation to the Medial Meniscus, *J. Bone & Joint Surg.* 25:121-131 (Jan.) 1943.

242. Anderson, R. L.: Dislocation of the Knee: Report of Four Cases, *Arch. Surg.* 46:598-603 (May) 1943.

243. Clarke, H. O.: Dislocation of the Knee-Joint with Capsular Interposition, *Proc. Roy. Soc. Med.* 35: 759 (Oct.) 1942.

in which dislocation of the knee was treated by open reduction. Cubbins, Callahan and Scuderi<sup>244</sup> consider injuries of the ligaments of knee joints caused by dislocation of the knee. The most common injuries of the ligaments are: (1) avulsion of the collateral tibial ligament and (2) rupture or avulsion of one or both cruciate ligaments, accompanied by rupture or avulsion of the collateral tibial and the collateral fibular ligament. Abnormal anteroposterior motion of the tibial plateau on the head of the femur with the knee flexed to 90 degrees, lateral motion of the straight knee and anteroposterior slipping of the tibial plateau on the femoral condyle are evidence of rupture or avulsion of the cruciate ligaments. For injury of the collateral tibial ligament the affected limb was immobilized for eight to ten weeks in complete extension. Recovery has been perfect. Complications of dislocation of the knee joint are injuries of blood vessels and nerves in the popliteal space. Treatment of complications consists of reduction of the dislocation, elevation of the involved limb and application of external heat. If the vascular supply is inadequate, amputation may be necessary.

Peirce and Eaglesham<sup>245</sup> report 8 cases of injury of the knee associated with fracture of the tibia in which lateral roentgenograms, made with the patient in the supine position, disclosed hydrarthrosis.

Pelner<sup>246</sup> reports 4 cases (and 3 control cases) of traumatic hydrarthrosis of the knee joint in which treatment consisted of a diet that was low in sodium chloride and contained acid-producing foods or foods that yielded a neutral ash on combustion. The ingestion of fluids was not limited. He found that an effusion into a joint was removed rapidly by this means, just as edema fluid is removed.

Rupture of Tendons: Gamey<sup>247</sup> reports a case in which an old rupture of the quadriceps tendon was followed by a rupture of the opposite quadriceps tendon. Immediate repair of the last rupture produced a good result, which serves to emphasize the importance of early repair.

244. Cubbins, W. R.; Callahan, J. J., and Scuderi, C. S.: Dislocations of Knee Joint and Their Complications, *Indust. Med.* **12**:732-733 (Nov.) 1943.

245. Peirce, C. B., and Eaglesham, D. C.: Traumatic Lipohemarthrosis of the Knee, *Radiology* **39**:655-662 (Dec.) 1942.

246. Pelner, L.: The Rapid Removal of Excess Joint Fluid by Acid Salts: Experiments with Traumatic Hydrarthrosis of the Knee Joint, *Am. J. M. Sc.* **206**:498-503 (Oct.) 1943.

247. Graney, C. M.: Bilateral Rupture of Quadriceps Femoris Tendons with Six-Year Interval Between Injuries, *Am. J. Surg.* **61**:112-116 (July) 1943.

Injury of the Semilunar Cartilages: Callahan and Hagen<sup>248</sup> consider the symptoms and signs of injury of the semilunar cartilage and describe their method of treatment. They say that the most reliable sign and symptom are lock of the knee and pain over the involved meniscus. Their technic for removal of a semilunar cartilage is as follows: Without a tourniquet the meniscus is removed with the Lowe-Breck knife and a tonsil snare. An elastic bandage and a plaster cast are applied. The cast is bivalved on the second day, and "quadriceps setting exercises" are begun. Sutures are removed and weight bearing is begun in eight to ten days.

MacAusland<sup>249</sup> reviews 850 cases in which derangement of the knee joint was due to injury to the semilunar cartilages. [ED. NOTE.—This is a thorough report of the subject, and an abstract will not do justice to it. Persons interested in this subject should read the article.]

Caldwell,<sup>250</sup> King,<sup>251</sup> Kellam,<sup>252</sup> Alexander, Peterson and Lille,<sup>254</sup> Terhune, Eddleman, Thompson and Read,<sup>255</sup> Slocum and Moore,<sup>256</sup> MacKenzie and MacFarlane<sup>257</sup> and Hamilton and Finklestein<sup>258</sup> all wrote on the operative treatment of internal derangement of the knee joint in the armed services. Their articles deal particularly though not wholly with injuries of the menisci. [ED. NOTE.—The variations in operative technic and in postoperative treatment

248. Childress, H. M., and Hagen, W. H.: Practical Aspects of Diagnosis and Surgical Treatment of Meniscus Injuries, *Mil. Surgeon* **93**:301-305 (Sept.) 1943.

249. MacAusland, W. R.: A Study of Derangement of Semilunar Cartilages Based on 850 Cases, *Surg. Gynec. & Obst.* **77**:141-152 (Aug.) 1943.

250. Caldwell, G. D.: Internal Derangement of the Knee Joint, *Mil. Surgeon* **92**:648-653 (June) 1943.

251. King, B. B.: Knee Joint Arthrotomy in Military Life, *Am. J. Surg.* **62**:382-386 (Dec.) 1943.

252. Kellam, H. I. J.: Knee Cartilages, abstract *Glasgow M. J.* **138**:5-6 (Dec.) 1942.

253. Alexander, J. C.: Knee Injuries in the Army, *Glasgow M. J.* **140**:12-15 (July) 1943.

254. Peterson, T. H., and Lille, J. J.: Injuries of the Semilunar Cartilages of the Knee, *U. S. Nav. M. B.* **41**:1336-1338 (Sept.) 1943.

255. Terhune, S. R.; Eddleman, T. S.; Thompson, E. B., and Read, B. S.: The Care of the Knee Following Excision of a Meniscus, *J. Bone & Joint Surg.* **25**:663-669 (July) 1943.

256. Slocum, D. B., and Moore, D. E.: Postoperative Horn Lesions in Meniscal Injury, *Surg., Gynec. & Obst.* **77**:87-90 (July) 1943.

257. MacKenzie, D. W., and MacFarlane, J.: Internal Derangements of the Knee Joint in the Canadian Army (Overseas), *Canad. M. A. J.* **49**:424 (Dec.) 1943.

258. Hamilton, A. S., and Finklestein, H. E.: Result of Meniscectomy (Knee Joint) in the South. M. J. **36**:406-411 (June) 1943.

are so great as to leave one in doubt as to which regimen is best. It is to be hoped that the various surgeons general may be able to produce a composite picture of the results so that a satisfactory routine may be established.]

Levinthal<sup>259</sup> reviews the anatomy of the knee and gives a classification of the internal and external derangements. Of 600 cases in which operation was performed on the knee, he found lesions of the internal semilunar cartilage in 41 per cent, lesions of the external semilunar cartilage in 6 per cent, lesions of both semilunar cartilages in 2.7 per cent, lesions of the infrapatellar fat pad in 4.7 per cent, osteochondromatosis in 2 per cent and various other conditions in the remainder of the cases. He noted that 50 per cent of the tears of the internal semilunar cartilage were of the bucket handle type.

Moorhead and Lyall<sup>260</sup> report 189 cases in which a similar type of arthrotomy was performed on the knee joint. They advocate a large medial incision. In 77, or 64 per cent, of 121 cases of recent injury of the cartilage there were other abnormalities of sufficient degree to warrant surgical treatment. Most of these effects would not have been seen if small incisions had been made.

*Gunshot Injuries.*—Buxton<sup>261</sup> considers the treatment of gunshot injuries. In the forward areas of the war zone the leg is immobilized in extension in a Thomas splint. The wound alone is dressed. At the base hospital the joint is aspirated and foreign bodies are removed immediately if the wound is infected. If the wound is not infected two or three weeks is allowed to elapse before the foreign bodies are removed. Early movement is encouraged in cases in which there is no infection. In cases of expected ankylosis, the knee should be kept straight, not hyperextended.

Fridland,<sup>262</sup> in writing on the same subject, says that wounds of the knee joint are divided to two groups: (1) penetrating injuries and (2) periarticular injuries. In periarticular injuries, infection of the joint may develop later than it does in penetrating wounds. In the former the infection spreads along fracture planes. Open wounds are closed in twelve to sixty hours

if sulfonamide drugs have been applied to the wound within a few hours. Foreign bodies are removed, and the joint cavity is mopped with 25 to 95 per cent alcohol and liberally treated with sulfonamide drugs in powder form. The synovial membrane is closed with silk sutures, and the wound is packed lightly with dry gauze. A plaster cast is applied from the ankle to the hip. A window is cut over the site of the injury. The packing is removed in twenty-four to forty-eight hours, and the wound is treated with hypertonic solution of sodium chloride if a thick discharge is present or with oily dressings if a thin discharge is present. Early passive movements are recommended, and in three to four weeks the patient is allowed to walk with crutches. Any effusion into the joint is aspirated, and the joint is irrigated with 1:500 solution of 2,ethoxy-6,9-diaminoacridinium hydrochloride (rivanol) or with a 3 per cent solution of phenol. In case the temperature remains high after five aspirations, drainage is advocated, with the patient on his side. Secondary resection of the joint is advocated for superficial osteomyelitis. Amputation should not be unduly delayed in cases of advanced sepsis.

*Dislocation of the Patella.*—Vallinkoski<sup>263</sup> reviews the results of the treatment of recurrent dislocation of the patella with the Krogus operation. He concludes that the results are good in cases of simple recurrent dislocation, but he does not recommend this procedure for the complicated type of dislocation.

*Osteochondral Fracture of the Patella.*—Milgram<sup>264</sup> describes what he calls "tangential osteochondral fracture" of the patella. He points out that this lesion is a purely traumatic avulsion of the cartilage from the patella and says that it must be distinguished from osteochondritis dissecans.

*Flexion Deformities of the Knee.*—Kuhns<sup>265</sup> and Reich<sup>266</sup> both review their experience with the correction of flexion deformities of the knee. Both of these articles are good, and it is suggested that they be read by any one desiring information on this subject.

263. Vallinkoski, T. V.: Ueber Behandlungsergebnisse der sogenannten habituellen Kniescheibenverrenkung mit der Operation von Krogus, *Zentralbl. f. Chir.* 69:1232-1234 (July 25) 1942.

264. Milgram, J. E.: Tangential Osteochondral Fracture of the Patella, *J. Bone & Joint Surg.* 25:271-280 (April) 1943.

265. Kuhns, J. G.: Treatment of Arthritic Contractures of the Knee, *New England J. Med.* 227:975-980 (Dec. 24) 1942.

266. Reich, R. S.: Treatment of Flexion Deformities of the Knee, *Surgery* 13:746-754 (May) 1943.

259. Levinthal, D. H.: Surgery of Derangements of the Knee Joint, *S. Clin. North America* 23:181-203 (Feb.) 1943.

260. Moorhead, J. J., and Lyall, D.: The Surgical Treatment of Intrinsic Knee Joint Lesions: Further Analysis of Operative Cases, *Ann. Surg.* 117:140-151 (Jan.) 1943.

261. Buxton, S. J. D.: Gunshot Wounds of the Knee Joint, abstracted, *Bull. War Med.* 3:506 (May) 1943.

262. Fridland, M. O.: Gunshot Wounds of the Knee Joint, abstracted, *Bull. War Med.* 4:17-18 (Sept.) 1943.

**Knock Knees.**—Lloyd<sup>267</sup> points out that valgus ankles rather than rickets are the forerunners of knock knees. As a preventive, he advocates corrective shoes, but in cases in which such treatment does not prove satisfactory he advocates the use of a special splint.

**Infection.**—Bercovitz<sup>268</sup> says that suppurative arthritis of the knee due to *Haemophilus influenzae* is rather uncommon. This condition primarily affects infants less than 2 years of age and rarely affects adults. Complete recovery is to be expected, whether surgical or expectant treatment is employed.

The author reports a case in which the disease involved the left knee of a Negro girl aged 15 months. The aspirated purulent fluid from the knee produced a pure culture of *H. influenzae*. Treatment consisted of traction, aspiration, blood transfusion and oral administration of sulfonamide drugs. The patient recovered completely.

**Tumors.**—Meyerding and VanDemark<sup>269</sup> report 15 cases in which a popliteal cyst was removed. The symptoms were aching, stiffness and consciousness of a mass in the popliteal space. In the differential diagnosis one must consider lipoma, xanthoma, fibrosarcoma, aneurysm, arteriovenous fistula or hemangioma, infectious swelling and Charcot's joint. Haggart<sup>270</sup> made a similar review of 34 cases. A case of synovium of the knee is reported by Eveleth and Brezina.<sup>271</sup> Harmon<sup>272</sup> and Wallace and Ghormley<sup>273</sup> report cases of hemangioma of the knee. Harmon discusses the diagnosis and treatment of this condition.

Ghormley and Dockerty<sup>274</sup> report 4 cases in which myxomatous tumors around the knee joint

were thoroughly studied grossly and cally. They compare these tumors with cysts. They conclude that cysts of the cartilage are not true neoplasms but result of degeneration. Such cysts contain an endothelial lining and thus Baker's cysts and other cystic lesions about the knee joint.

**Röntgenographic Examination.**—Chance<sup>275</sup> advocates a method of air arthrography and Somerville<sup>276</sup> reports the use of the Clausen<sup>277</sup> describes the use of a contrast which consists of a mixture of 10 cc. of 1 per cent solution of perabrodil (same as and 5 cc. of a 0.5 per cent solution of hydrochloride. This contrast medium removed from the joint. Möhlmann and Madlener<sup>278</sup> used gas as a contrast medium.

**Surgical Procedures.**—Cozen<sup>279</sup> suggests a different technic for exposing the medial meniscus of the knee joint. He says that the patient in a prone position and the knee operated on in full flexion better view of the posterior portion of the semilunar cartilage is obtained. He has operated on 15 knees by this technic. Mitchell<sup>280</sup> describes the meniscotomy knife, similar in principle to that of Breck and Lowe and other surgeons. Coonse and Adams<sup>281</sup> describe what they term the "operative approach to the knee joint." In this approach a paramedial incision is made. A Y incision with the stem of the Y pointing proximally is made through the quadriceps tendon 2 inches (5 cm.) above the patella and continuing down and around the patella about ½ inch (0.6 to 1.3 cm.) away from it. The patella is retracted downward, and full exposure of the knee joint is afforded. The authors state that the advantage of this approach is the

267. Lloyd, E. I.: Knock-Knees and Bow-Legs, *Practitioner* **150**:238-244 (April) 1943.

268. Bercovitz, G. D.: Suppurative Arthritis Due to *Cillius Hemophilus Influenzae*, *Bull. Hosp. Joint Dis.* **11**:43 (April) 1943.

269. Meyerding, H. W., and Van Demark, R. E.: Posterior Hernia of Knee (Baker's Cyst, Popliteal Cyst, Pseudomembranous Bursitis, Medial Gastrocnemius Bursitis and Popliteal Bursitis), *J. A. M. A.* **122**:858-861 (July 24) 1943.

270. Haggart, G. E.: Synovial Cysts of the Popliteal Space: Clinical Significance and Treatment, *Ann. of Surg.* **118**:438-444 (Sept.) 1943.

271. Eveleth, M. S., and Brezina, P. S.: Synovium of the Knee Joint: Case Report, *Yale J. Biol. & Med.* **16**:27-30 (Oct.) 1943.

272. Harmon, P. H.: Hemangioma of the Synovial Membrane of the Knee Joint Cured by Synovectomy, *Ch. Surg.* **47**:359-363 (Oct.) 1943.

273. Wallace, G. T., and Ghormley, R. K.: Cavernous Hemangioma of Knee, *Proc. Staff Meet., Mayo Clin.* **18**:177-182 (June 16) 1943.

274. Ghormley, R. K., and Dockerty, M. B.: Cystic Myxomatous Tumors About Knee; Their Relation to That of Menisci, *J. Bone & Joint Surg.* **25**:306-318 (April) 1943.

275. Cullen, C. H., and Chance, G. Q.: Air Arthrography in Lesions of Semilunar Cartilages, *Brit. Surg.* **30**:241-245 (Jan.) 1943.

276. Somerville, E. W.: Air Arthrography in Diagnosis of Internal Derangement of Knee Joint, *Proc. Roy. Soc. Med.* **36**:663-664 (Oct.) 1943.

277. Clausen, A.: Question of Positive or Negative Contrast Substances of Knee, *Fortschr. a. d. Geb. Röntgenstrahlen* **65**:76-80 (Feb.) 1942.

278. Möhlmann and Madlener: Using Contrast Substance; Demonstration of Menisci Lesions in Röntgenograms Obtained During Simultaneous Abduction, Flexion and Rotation of the Knee, *Fortschr. a. d. Geb. Röntgenstrahlen* **65**:51-76 (Feb.) 1942.

279. Cozen, L. N.: Prone Position for Exposure of Medial Meniscus of Knee Joint, *Arch. Surg.* **46**:612 (May) 1943.

280. Mitchell, A.: Meniscotomy Knife, *Lancet* **1**:125 (April 24) 1943.

281. Coonse, K., and Adams, J. D.: A New Operative Approach to the Knee Joint, *Surg., Gynec. & Obst.* **77**:344-347 (Oct.) 1943.

affords adequate exposure of this joint with a minimum of trauma of soft tissue by retraction. [ED. NOTE.—It is my impression that such an extensive incision is not necessary in most procedures on the knee joint.]

**Reconstruction of Crucial Ligaments:** Albee<sup>282</sup> describes a new operation for repair of the crucial ligaments. Through a split patellar incision the joint, the femoral condyle and the upper part of the tibia are exposed. Holes are drilled through the outer condyle of the femur from an anterior external point to a point in the intercondylar notch and from the anterior portion of the tibia into the intercondylar spines of the tibia. Fascia lata from the thigh is threaded through and wedged into the drill holes with bone plugs. The drill holes are varied in position, according to the type of instability present. Novillo Martinez<sup>283</sup> describes a method of repairing the anterior crucial ligament by passing a strip of fascia lata through the external condyle and the internal tuberosity and fixing it to the neighboring tissues. Perez Zabala<sup>284</sup> reviews several cases in which the anterior crucial ligament was repaired.

282. Albee, F. H.: A New Operation for the Repair of the Crucial Ligaments of the Knee, *Am. J. Surg.* 0:349-353 (June) 1943.

283. Novillo Martinez, L.: Reconstruction of Anterior Crossed Ligaments (Groves Technic), *Bol. y Trab., Soc. de cir. de Córdoba* 3:322-327, 1942.

284. Perez Zabala, M.: Reconstruction of Ligaments of Knee, *Bol. d. Inst. clín. quir.* 18:645-661 (Sept.) 1942.

[ED. NOTE.—The frequency with which methods of repair of the anterior crucial ligaments are described emphasizes the unsatisfactory results obtained with these procedures.]

**Patellectomy:** Urrutia<sup>285</sup> reports 2 cases in which patellectomy was performed. In 1 case it was performed for tuberculosis, and in the other case it was performed for staphylococcal osteitis. Tuberculous arthritis developed in the first case, but a satisfactory functional result was obtained in the second case.

**Synovectomy:** McKeever<sup>286</sup> advocates the use of cellophane as an interposing membrane in cases in which synovectomy is performed. He reports 4 cases in which this material was used.

**Arthrodesis:** Hatt<sup>287</sup> states that fusion of the knee by a central graft does not cause arrest of growth, probably because of the mode of growth in length of a bone. As pointed out by Aries, longitudinal growth of bone does not take place in the form of lines parallel to the epiphysal disk but by successive cones from the endosteal surface, each new cone having for its base the peripheral portion of the disk and possessing a wider perimeter than the old. Of 67 cases in which a fusion operation was performed, 44 were studied to evaluate the result on growth of bone.

285. Urrutia U., C.: Patellectomy for Osteitis: Two Cases, *Rev. méd. de Chile* 71:675-678 (July) 1943.

286. McKeever, D. C.: The Use of Cellophane as an Interposition Membrane in Synovectomy, *J. Bone & Joint Surg.* 25:576-580 (July) 1943.

287. Hatt, R. N.: Central Bone Graft in Joint Arthrodesis, *Arch. Surg.* 46:664-665 (May) 1943.

## IX. FRACTURES

PREPARED BY WALTER G. STUCK, M.D., SAN ANTONIO, TEXAS; R. BEVERLY RANEY, M.D., DURHAM, N. C.; JOHN J. FAHEY, M.D., CHICAGO; DON H. O'DONOGHUE, M.D., OKLAHOMA CITY, AND HERMAN F. JOHNSON, M.D., OMAHA

In spite of war and confusion, able and numerous articles have been published in the surgical journals on all phases of the treatment of fractures. In 1943 more articles on war wounds, fatigue fractures and devices for external fixation appeared than in former years. We have tried to make a fair appraisal of them and to submit reviews of those we consider most timely. Any oversights are more than likely due to the endless demands on the reviewers in these parlous times.

**Fractures of the Face and Jaw.**—It is more and more apparent that fractures of the face and jaw require free interchange of opinion among dentists, plastic surgeons and orthopedic surgeons if best results are to be obtained. This is especially true of the more severe crushing and compound injuries.

In a statistical study of 1,149 cases of fracture of the facial bones, Lyons<sup>288</sup> notes these sig-

nificant facts: Fifty-one of the fractures resulted from automobile accidents, while industrial accidents caused about 32 per cent. Thirty per cent of the fractures involved the maxilla and 70 per cent the mandible. The right side of the face is more vulnerable to fractures than the left side. One of the greatest complications of fractures of the jaw is loss of teeth. It must always be borne in mind that fractures of the skull may coexist with fractures of the facial bones.

Winter<sup>289</sup> reports 50 cases in which he used the Roger Anderson skeletal fixation appliance

288. Lyons, D. C.: Care of Military and Civilian Injuries: Fractures of Mandible, Maxilla, Zygoma, and Other Facial Bones; Statistical Study of 1,149 Cases, *Am. J. Orthodontics (Oral Surg. Sect.)* 29:67-76 (Feb.) 1943.

289. Winter, L.: Fractures of the Mandible: Report of Fifty Applications of Roger Anderson Skeletal Fixation Appliance, *Am. J. Surg.* 61:367-379 (Sept.) 1943.

for fractures of the mandible. In the article are excellent diagrams of the anatomy of the cheek and jaw and photographs of the equipment used. This device is preferred over all others because it is easy to apply, it produces secure fixation of the fragments without immobilizing the jaw and it simplifies nursing care. There are a few relatively unimportant pitfalls, which are described.

For edentulous jaws, or those with too few teeth, external supports are essential for the proper immobilization of the fractured fragments. Since 1940 Bigelow<sup>290</sup> has developed a method whereby vitallium screws are inserted into the mandible from the outside. At first the screws in the bone were united by a splint of strap iron or dural. Now, however, the screws are fastened to a vitallium alinement bar, which supports the fracture. Sometimes it is preferable to insert a vitallium screw into the jaw and provide traction from it to a plaster head piece. [ED. NOTE (W. G. S.).—An external vitallium bar to connect the vitallium screws is preferable to any other metal bar. As Venable and Stuck demonstrated in 1936, dissimilar metals in the body set up sufficient electrolytic activity to cause erosion of bone and loosening of screws.]

For edentulous jaws Ivy and Curtis<sup>291</sup> have used the Roger Anderson apparatus or the Carl Waldron device for external fixation. Two cases are reported in which the latter appliance was used with great success.

Wiring of teeth for fractures of the mandible is uncomfortable and makes for poor oral hygiene. External fixation devices are hard to keep clean and are subject to accidental motion. Pincock<sup>292</sup> has devised a method of drilling a Kirschner wire longitudinally through the body of the mandible and cutting the ends so that the fracture is well supported and yet no external apparatus is visible. The only difficulty is in guiding the wire, and in this article an excellent guide is described, which facilitates the operation.

Berry,<sup>293</sup> who has in the past devised various methods for external fixation of fractures of the jaw, reports a case in which the fracture

was fixed with metal staples. With the patient under intravenously induced anesthesia, the fracture was reduced and two metal staples were driven through the skin into the two fragments of bone. No preliminary incision was made and no holes were drilled. The fixation seemed adequate, and the fracture healed with the bone in a normal position.

Skinner and Robinson<sup>294</sup> point out that the fragments of a fractured mandible seldom fail to unite, even in the presence of compound wounds and infections. A bone graft from the ilium, which is held in place by silver wire, and a dental splint will bridge the defect adequately. Even so, the jaw must be splinted for three months to assure proper fixation while healing is taking place.

Adams<sup>295</sup> has abandoned extraoral appliances for the immobilization of facial fractures. Open reduction and fixation by wiring the fractured parts to the neighboring unfractured bones are performed in all cases in which immobilization is indicated. This type of treatment is applicable to every type of fracture involving the facial bones. The procedure is carried out with only a pair of pliers, a small drill and dissection set and a spool of stainless steel wire. Repeated adjustments are unnecessary; the patient is spared much discomfort and inconvenience and is able to resume his activities after recovery from the acute stage of the injury. Open operation is contraindicated in the presence of infection. For fractures of the maxilla, a small incision is made over the infraorbital ridge, and a drill hole is made. A wire is threaded through the opening and looped over the ridge, and both ends are passed together along the anterior wall of the antrum to the region of the second molar teeth. The fractured bone is elevated to its normal position and is wired to the teeth. Several illustrations demonstrate the results of treating fractures of the maxilla and malar bones. [ED. NOTE (J. J. F.).—This is an excellent article, and the reader who is interested in this phase of work should resort to the original.]

*Fractures of the Spine and Pelvis.*—Conwell<sup>296</sup> uses a Herzmark frame to accomplish reduction of spinal fractures. After emergency treatment for shock has been given, with the

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293. Berry, H. C.: Simple Skeletal Fixation Method for Quick Repair of a Fracture in War Surgery, *J. Am. Dent. A.* 30:1377-1378 (Sept.) 1943.

294. Skinner, H. L., and Robinson, R. L.: Union in Fracture of the Mandible, with Report of a Case, *J. Oral Surg.* 1:162-167 (April) 1943.

295. Adams, W. M.: Internal Wiring Fixation of Facial Fractures, *Am. J. Orthodontics (Oral Sect.)* 29:111-130 (Feb.) 1943.

296. Conwell, H. E.: Nonparalytic Compression Fractures of the Spine, *J. Omaha Mid-West Clin. Soc.* 3:52-55 (April) 1942.

patient under the influence of opiates or tribromoethanol, hyperextension is obtained by means of a turnbuckle, fifteen to twenty minutes being necessary to obtain correction. It may also be necessary to apply traction to the head and foot. He contends that too severe manipulative procedures or too early application of a tight body cast may cause paralytic ileus. After reduction the patient is allowed to remain on the frame for a few days, after which time the plaster cast is applied. In certain cases an anteroposterior plaster shell may be used. If the economic status is good, the patient remains on the frame from five to six weeks; then a cast is applied and is worn six weeks. A Taylor brace is then worn until roentgenograms show restoration of the fractured vertebrae. He points out that renal stones developed in a number of his patients. [ED. NOTE (J. J. F.).—This author has well emphasized the importance of avoiding early manipulation and immobilization with a cast, so as to avoid paralytic ileus.]

In the Kolar gold field, Dunkerley<sup>297</sup> saw 50 cases of fracture of the vertebrae, with evidence of damage to the spinal cord in only 4 cases. He preferred the Watson-Jones "two table method" of reduction. There was only one cervical dislocation in this series of cases. [ED. NOTE (W. G. S.).—This long article reviews all the details of anatomy, type of injury, and various plans of treatment and in addition gives a thorough account of the recent literature on vertebral fractures.]

Many men working in the Middle East were admitted to an Australian general hospital in 1942 with injuries of the cervical part of the spine. Many of these injuries were caused by the men diving from one another's shoulders into shallow water near the beaches. West<sup>298</sup> describes a light cast which he has devised for immobilizing the cervical portion of the spine in hyperextension. It consists of a waistband of plaster, two shoulder straps of plaster and a posterior prolongation which supports the back of the head and extends forward to the forehead.

A concise historical review of experimental and clinical work concerning injuries of the spinal cord is presented by Kennedy, Denker and Osborne.<sup>299</sup> They favor early laminectomy for

injuries to the spinal cord. The case histories of patients treated according to this principle are included. Early laminectomy is advocated for the following reasons: (a) It is impossible to determine clinically whether an apparently complete transverse lesion of the cord is not really a temporary physiologic interruption of function. Waiting from two to four weeks for "spinal shock" to subside is, according to the authors, a ridiculous procedure, (b) Negative results of a roentgenographic examination do not exclude a bony lesion of the spine. (c) Prolonged compression of the cord, as evidenced by manometric block, which might have been cured by early surgical treatment, can destroy function of the cord. (d) The operation is associated with little risk as soon as general shock has been treated. In the authors' opinion, an experimental study should be undertaken comparing early laminectomy with conservative or traction methods.

Taylor<sup>300</sup> discusses at length dislocation of the pelvis, including in particular dislocation of the symphysis pubis with accompanying sacroiliac subluxation. He discusses the incidence and recommends treatment with a sling or a similar apparatus. He is not impressed with the results of open operation for this condition.

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Fractures of the Humerus: Key<sup>303</sup> writes that for widely displaced fractures, fracture-dislocations and severely comminuted fractures of

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302. Masland, H. C.: A Positive Shoulder Lift for Fractured Clavicles, *Am. J. Surg.* 60:154-155 (April) 1943.

303. Key, J. A.: Wire Fixation of Fractures of the Proximal Third of the Humerus, *Arch. Surg.* 46:678-680 (May) 1943.

the proximal third of the humerus, injuries which are often difficult to treat by manipulation or traction, open reduction is frequently the best method of treatment. He describes briefly the operative technic. If the fragments are stable when reduced, no internal fixation is necessary. A powdered sulfonamide compound is placed in the wound, and after closure a Velpeau bandage is applied. Ten days later the cutaneous sutures are removed, a hanging cast is applied and exercises for the shoulder are started. To this more or less standardized method of treatment, Key contributes the idea of fixation of the fragments at operation by means of two Kirschner wires; these are put through the skin of the lateral and superior aspects of the shoulder and drilled backward and downward, crossing the fracture line. They give a quick and convenient fixation, and no foreign body is left after the wires are pulled out, two to three weeks after operation. [ED NOTE (R. B. R.).—This appears to be a useful means of internal fixation for fractures which are difficult to handle by other methods. It should be helpful occasionally for the slipped epiphysis of the humeral head of adolescents.]

Additional reports on the treatment of fractures of the upper end of the humerus without operation or cast are made by Brostrom<sup>304</sup> and Caldwell.<sup>305</sup> Brostrom reports experience with 97 cases, in 61 of which the surgical neck was involved, in 6 the shaft and in the remainder the tuberosities or the anatomic neck. In some cases reduction was carried out. Uniformly, however, an axillary pad was used and the arm fixed to the side of the body by a wide bandage which left the elbow free; the wrist was supported by a sling suspended from the neck. For three days the patients were treated with heat through the bandage, after which light effleurage of the entire extremity and exercises to extend the elbow were carried out daily, with passive circumduction at first and active circumduction later. The dressing around the arm and the chest was discarded in three to four weeks and the sling seven to ten days later. The patients received an average of twenty-three physical therapy treatments. Of eighty-two known end results, twenty-seven were excellent and thirty-two good. Brostrom considers this a superior method of treatment because no elaborate equipment is necessary, no prolonged recumbency is required, the patient is comfortable and stiffness

and traumatic arthritis are minimized. [NOTE (R. B. R.).—This, of course, is hanging cast treatment without the cast and might be called the hanging arm treatment. In most cases it is probably an excellent method. After fracture of the upper end of the humerus, avoidance of contractures is much more important than anatomic reposition of the fragments.]

R. S. H.,<sup>306</sup> whose full name is not given, enlivened the year's literature on fractures with an unimportant but amusing and well written case report entitled "The Place of Organized 'Elbow Lifting' in Treatment of the Fractured Humerus." The patient, a British squad leader, had a crack fracture of the surgical neck of the humerus and complete detachment of the greater tuberosity. His treatment began with active movement under water on the fourth day; the patient "enjoyed it immensely as the difficulties in normally getting a bath at E—, which is a widely dispersed and exquisitely uncomfortable camp, are enormous." Beginning on the ninth day he was forbidden to use his uninjured arm to raise any beverage to his mouth. This involved frequent and purposeful lifting of the elbow on the injured side. Times of treatment corresponded approximately with opening time of the bar. Half pints only were allowed to be used at first. Under the constant encouragement of many friends and under the pleasantly mellowing and possibly mildly anaesthetic effect of what was drunk, the patient succeeded in lifting his elbow to the level of the shoulder by the eleventh day." He was able to return to full ground duty in two weeks.

In a well presented article Stuck<sup>307</sup> describes the management of the various types of fractures involving the humerus. Incomplete fracture of the greater tuberosity, fracture of the anatomic neck and fracture of the surgical neck without displacement are treated with a sling. When traction fails in cases of fracture of the surgical neck with displacement, open reduction and fixation with a screw or wire are done. For fracture-dislocation of the humeral head, open reduction is usually necessary. Resection of the humeral head is not warranted for a fracture-dislocation. The hanging cast method offers advantages over the usual types of treatment for fracture of the shaft. Stiff shoulder is overcome by swinging exercises with this type of treatment. In cases in which the radial nerve

304. Brostrom, F.: Early Mobilization of Fractures of the Upper End of the Humerus, *Arch. Surg.* 46:614-615 (May) 1943.

305. Caldwell, G. A.: The Treatment of Fractures of the Upper End of the Humerus, *Rocky Mountain M. J.* 40:33 (Jan.) 1943.

306. The Place of Organized "Elbow Lifting" in Treatment of the Fractured Humerus, *St. Barth. Hosp. J.* 47:102 (March) 1943.

307. Stuck, W. G.: Anatomical and Mechanical Features of Treatment of Fractures of the Humerus, *South M. J.* 36:543-549 (Aug.) 1943.

is injured and there is no evidence of recovery in the first few weeks, the author assumes that the nerve has been lacerated or compressed and advises exploration. Flexion without manipulation does not reduce supracondylar fractures. It is necessary to exert downward traction and push the distal fragment forward as the elbow is flexed. Close observation of the radial pulse must be made subsequently. For fracture displacement of the internal or external humeral condyle, open operation and replacement with a nail or screw are recommended. Open operation and fixation either with screws or nails are used to treat T fractures of the lower end of the humerus. In cases in which there is severe comminution, operation is not advisable and early motion to prevent stiffness is carried out. [Ed. NOTE (J. J. F.).—In cases in which reduction cannot be accomplished by manipulation and in cases of comminuted fracture, traction by means of a screw through the upper end of the ulna has been found satisfactory.]

Smith<sup>308</sup> discusses the disadvantages of several methods of applying traction for fracture of the distal half of the shaft of the humerus with the patient in the recumbent position and presents an adaptation of Russell double pulley traction for treating this type of fracture. No unusual equipment is required, the vertical components are balanced and effective traction is exerted in the longitudinal axis of the arm. [Ed. NOTE (R. B. R.).—This appears to be a good method for the unusual fracture for which prolonged traction with the patient in recumbency is needed. Most fractures of this type can be satisfactorily handled by a hanging cast if the patient is ambulatory or by the application of traction to the cast near the elbow if the patient must remain in bed.]

Aitken, Smith and Blackett<sup>309</sup> have studied the end results in 50 cases of supracondylar fracture in childhood. Using a minimum follow-up period of three years, they have attempted to determine the results of malalignment and to develop a more satisfactory method of treatment. They found almost uniformly excellent function, but in 15 cases in which a varus deformity was present poor cosmetic results occurred. The authors concluded that, despite incomplete reduction, supracondylar fracture with radial displacement and external rotation of the distal fragment tends to show excellent functional and cosmetic end results. On the other hand, ulnar

displacement plus backward displacement or internal rotation of the distal fragment leads invariably to persistence of a varus deformity. The writers think that development of this deformity following a satisfactory reduction may well be due to the practice of placing the forearm across the chest; unless the fragments are tightly locked with the elbow in acute flexion, the forearm and the distal fragment may rotate inwardly on the humerus. To prevent this complication, they recommend a plaster swathe about the chest; this is fixed to the arm cast and holds the extremity externally rotated. They suggest that this may not be necessary when it is possible to maintain acute flexion of the elbow. They condemn the dictum that accurate reduction is not essential for a good result. [Ed. NOTE (R. B. R.).—This explanation of varus deformity after supracondylar fracture of the humerus is plausible and should make one most careful in correcting any medial or rotatory displacement of the distal fragment. In the cast the elbow must be kept acutely flexed, and the cast must be sufficiently tight to prevent movement at the elbow. With preliminary adhesive traction in those cases in which swelling has resulted from a delay in treatment, the right angle position and the cast around the chest will probably not be necessary in a great number of instances.]

de Abreu<sup>310</sup> calls attention to the complex problems of supracondylar fracture of the humerus and emphasizes the fact that a perfect knowledge of the anatomy of the region with application of good conservative orthopedic treatment may limit surgical indications and lead to good anatomic as well as functional results.

Fractures of the Proximal End of the Radius: Burton<sup>311</sup> reviews 50 consecutive cases of fracture of the head of the radius observed in Royal Air Force personnel. He has classified the fractures into three groups, as follows: 1. Impaled fracture, resulting from a fall on the outstretched pronated hand. The author states that the cartilage of the capitellum is usually injured with this type of fracture and that a roentgenogram made two weeks after the injury may show evidence of this. 2. Marginal fracture, resulting from an abduction strain on the elbow with the forearm pronated. A segment of the articular surface of the head is fractured and may not be displaced. An injury of the capitellar cartilage sometimes occurs. 3. Undisplaced fissure

308. Smith, D. W.: Double Pulley Humeral Adaptation of Russell Traction, *Surgery* 13:62-66 (Jan.) 1943.

309. Aitken, A. P.; Smith, L., and Blackett, C. W.: Supracondylar Fractures in Children, *Am. J. Surg.* 59: 161-171 (Feb.) 1943.

310. de Abreu, M.: Humerus Fractures: Complete Supracondylar Fracture. *Rev. brasil. de ortop. e traumatol.* 3:245-260 (July-Aug.) 1942.

311. Burton, A. E.: Fractures of the Head of the Radius, *Proc. Roy. Soc. Med.* 35:764-765 (Oct.) 1942.

fracture, resulting from direct injury of the elbow and consisting of a transverse fissure without displacement. The author considers excision of the head advisable for nearly all impaled fractures. Excision was performed for marginal fractures when the segment was displaced or the integrity of the articular plateau disturbed. For marginal fractures without displacement and for fissure fractures, conservative treatment was carried out. The percentage of good results was notably poor only in a group of 9 impaled fractures which were treated without operation, only 2 of these obtaining a good result. The author noted no instability of the superior or the inferior radioulnar joint, cubitus valgus or formation of new bone after operation. [ED. NOTE (R. B. R.).—This classification is interesting; it is to be regretted that the text is not accompanied by illustrations. The absence of complications may possibly be due to a short follow-up period, no definite time being stated.]

Mason and Shutkin<sup>312</sup> contrast favorably treatment of fractures of the head and neck of the radius by immediate active motion with conventional treatment with a cast. They point out that their observations apply only to fractures without displacement or with minimal displacement and that their follow-up period of less than a year is inadequate. The patients treated by early active motion were given a sling, continuous hot wet packs to overcome muscular spasm and active exercise of the elbow twice daily. The authors found that the group treated by early active motion and without a cast had a shorter stay in the hospital, less calcification in the soft tissues and better function of the elbow than the group treated by conventional methods. They think that these advantages may be due to several factors. The fractured fragments are small and uncontrollable; early active motion may permit them to be moved across the fixed articular surface of the humerus to attain the position where maximum function is possible; local heat in the form of hot packs permits early elimination of the reaction of soft tissues and lessens the tendency toward calcification of soft tissues. [ED. NOTE (R. B. R.).—The details of therapy for the 7 patients treated "conventionally" are not given; consequently, a comparison with the other method is invalidated to a large extent. It is questionable that hot packs are the best treatment for the acutely injured elbow.]

312. Mason, J. A., and Shutkin, N. M.: Immediate Active Motion Treatment of Fractures of the Head and Neck of the Radius, *Surg., Gynec. & Obst.* 76:731-737 (June) 1943.

Fractures of the Carpal Scaphoid Bone: Childress<sup>312a</sup> records a case of fracture of distal fragment of a bipartite carpal scaphoid bone in which malunion of the distal fragment occurred. He emphasizes the advisability of comparing roentgenograms of the injured bone with those of the scaphoid bone of the uninjured wrist. He also points out that the line of division of a bipartite scaphoid bone runs obliquely from near the outer end of the articular surface of the radius to about the middle of the convexity of the head of the capitate bone.

Fractures of the Hand: In a report of cases of fracture of the metacarpal bones, Cob Hansen and Morris<sup>313</sup> present a method of securing traction with a towel clip in the bone with rubber bands fastened to a wire loop. There were no infections, because aseptic surgical technique was used, preliminary incisions were made in the skin and the towel clips, unlike wires, did not permit side to side motion. The authors present evidence to show that excellent position can be secured and fractures can be perfectly immobilized by this novel method.

Berkman and Miles,<sup>314</sup> on the basis of 20 cases describe a method of splinting fractures of the metacarpal bones by passing one or two Kirschner wires through the fractured bone into the adjacent sound bone. Fixation of this type is so secure that no cast or external splint is needed. They state that men in the army are able to perform light duty in three or four days after this procedure.

Rosa dos Santos<sup>315</sup> draws attention to the high incidence of fractures of the base of the first metacarpal bone and emphasizes the serious sequelae of improper treatment. He presents a classification of the various anatomopathologic types and discusses the mechanism of the lesions and their respective therapeutic indications. He describes 3 cases in detail.

*Fractures of the Lower Extremity.*—Fractures of the Femur: Lutz<sup>316</sup> reviews the treatment of fractures of the femur, particularly compound fractures as they occur on the battle-

312a. Childress, H. M.: Fracture of a Bipartite Navicular, *J. Bone & Joint Surg.* 25:446-447 (April) 1943.

313. Cobey, M. C.; Hansen, H. C., and Morris, M. H.: Use of Skeletal Traction in the Hand, *Army M. Bull.*, July 1943, no. 68, pp. 135-141.

314. Berkman, E. F., and Miles, G. H.: Internal Fixation of Metacarpal Fractures Exclusive of the Thumb, *J. Bone & Joint Surg.* 25:816-821 (Oct.) 1943.

315. Rosa dos Santos, W.: Metacarpus Fractures: Bennett Fracture with Report of Cases, *Rev. brasil. de ortop. e traumatol.* 4:1-14 (Jan.-Feb.) 1943.

316. Lutz, A. R.: Fractures of the Shaft of the Femur: A Review of Treatment of Femoral Shaft Fractures, *West Virginia M. J.* 39:111-114 (April) 1941.

field. The first principle is the treatment of hemorrhage and shock. Morphine is given and replacement of fluid in the form of blood or plasma started as soon as possible when indicated. Prophylaxis of infection is carried out by local application of sulfonamide compounds and sterile dressings. Débridement is done as soon as possible, preferably before six hours. After twelve hours it is contraindicated. Sulfonamide drugs are given orally and applied locally, and the author presents a routine for cleansing wounds. Complete immobilization is advocated, and the different methods for this as well as for traction and fixation are outlined. The author lists skeletal traction with a Kirschner wire and as much as 35 pounds (15.9 Kg.) as the preferable method. He emphasizes, however, that even under ideal conditions no single method is adequate in all cases. Mention is made of the Haynes apparatus and the Roger Anderson fracture unit.

Joldersma<sup>316a</sup> describes experiences with the use of the Townsend-Gilfillan stainless steel plate in the operative fixation of fractures of the tibia and femur. This report is not a chronicle of a series of cases but rather a development of the theory of application of this type of fixation. The plate, which has been described in other publications, derives its strength from the fact that it is built like an angle iron bridge girder, with slots in the shank for screw holes. The plates can be stacked; it is claimed that two-nested plates give five times the support of a single plate. Joldersma states that it is unnecessary to use casts as auxiliary support after the use of the screws and plates described, citing 14 of 15 cases of fracture of the tibia as proof of this contention. The claim of the author that "obliteration of the fracture line occurred in four weeks and solid union was observed in eight weeks" may be disputed by many surgeons who have had contrary experience. The following rules are given to guide the surgeon: (1) Acute clean fractures if seen within five hours are plated immediately; (2) fractures more than six hours old are put in suspension traction for fourteen days, and (3) compound fractures are plated after two or three weeks. The main conclusion of this article is to the effect that return to full duty after fracture of the tibia can be reduced from seven months to three and after fracture of the femur from nine months to five.

The well known Thomas walking caliper splint with round or oval ring has not met the requirements of a weight-bearing splint which will transmit pressure evenly to the tuberosity of

the ischium. Young<sup>317</sup> has devised an ischium-bearing brace that seems to present several advantages. The half-ring is modeled to fit the ischial tuberosity snugly without pressure on the adductor muscles. The hinge at the ankle is placed directly opposite the ankle joint, so that there is no movement of the brace when the ankle is moved. The brace is carefully described and well illustrated for the guidance of the brace maker.

Schenken and Coleman<sup>318</sup> state that embolism of bone marrow after fracture of a long bone has not been described. They report the case of an 86 year old woman with a fracture of the neck of the femur, which was treated by the insertion of three screws. The patient died four days later. Pathologic examination of the lungs revealed emboli of bone marrow in branches of the pulmonary artery.

Pollock and Brooks<sup>319</sup> describe a device for mobilizing the lower extremity after operation or injury. It consists of a splint to hold the extremity, with joints that can be moved by the patient and a wheel and rail to facilitate the motion. It is especially useful in encouraging motion of the hip and knee in elderly persons with arthritis.

Pridie<sup>320</sup> states that compound fractures of the femur occurring as a result of road accidents in peacetime necessitate only a plain sterile bandage for the wound and splints applied down the side of the body. The patients are usually in the hospital within a few minutes after the accident. Casualties of an air raid who can be transferred rapidly to a hospital need similar first aid treatment. The author saw no Thomas splints used during the Bristol air raids, and the patients reached the hospital in good condition. As he points out, many of the patients had large lacerated wounds of the buttocks, which would have prevented use of Thomas splints. The transportation of war casualties is often over rough ground, so that extensive immobilization is required, preferably with a cast. Since evacuation may take many hours, sulfonamide drugs must be used in the wound whenever possible. In Libya a plaster spica cast with an incorporated Thomas splint to maintain traction on the leg

317. Young, C. S.: A Half-Ring Splint for Fractures of the Femur and Tibia and for Other Disabilities of the Lower Extremity, *Surg., Gynec. & Obst.* 77:518-522 (Nov.) 1943.

318. Schenken, J. R., and Coleman, F. C.: Bone Marrow and Fat Embolism Following Fracture of the Femur, *Am. J. Surg.* 61:126-127 (July) 1943.

319. Pollock, G. A., and Brooks, G.: The "Railed" Splint, *Brit. M. J.* 2:638 (Nov. 28) 1942.

320. Pridie, K. H.: Compound Fractures of the Femur, *M. Press* 209:231-233 (April 14) 1943.

316a. Joldersma, R. D.: Fallacies of Bone Plating, *Am. J. Surg.* 60:50-55 (April) 1943.

was found to be the most satisfactory of all splints. However, it was learned by tragic experience that such casts should be split along the involved side to prevent constriction and circulatory obstruction. [Ed. NOTE (W. G. S.).—The plaster of paris spica cast with the incorporated Thomas splint has now become justly popular as "the Tobruk splint."]

Caldwell<sup>321</sup> analyzes the end results in 42 patients with subtrochanteric fracture of the femur. Of 36 patients treated without operation but with Russell traction or a Thomas splint, 2 died and union resulted in all 34 survivors. Two were not able to bear weight before eight months, and in others shortening resulted. On 5 operation was performed with the posterior approach. A cast was made prior to operation and hivalved. The patient was placed face down on the table, and an incision was made along the posterior border of the fascia lata beginning with the greater trochanter and extending downward 8 to 10 inches (20.3 to 25.4 cm.). The biceps femoris muscle was separated from the vastus lateralis muscle; exposure was easy, and reduction was maintained by bone plates. In all cases union was prompt, with good results. [Ed. NOTE (J. J. F.).—While this may be a rational procedure for the experienced surgeon, it would seem that it should not be performed by the occasional operator.]

In a study of 77 cases of lateral fracture of the femoral neck, Pique and Valls<sup>322</sup> found that all of the fractures consolidated. Skeletal traction was shown to be superior to the Whitman cast, the anatomic and functional results being definitely superior. Skeletal traction diminishes the morbidity and the mortality rate during treatment since it permits easier therapeutic measures. Best results are obtained if skeletal traction is maintained to the end of cure, in order to avoid possible displacement of the fragments.

Williams<sup>323</sup> describes an emergency splint for the fractured femur (and adjustable for the bones of the leg) made up entirely of personal equipment, which can be applied by two untrained men in the absence of skilled assistance. The wounded man is placed in an extended position, with limbs together. One man grasps the heel and foot of the injured limb, extends the limb

steadily and maintains the extended position until bandaging is complete. The other man puts a rifle along the outer side, with the butt up to the arm pit, first removing the bolt insuring that neither rifle nor magazine contain any cartridges; he then extracts a pull-through cord, ties the patient's boot laces together with a large handkerchief or field dressing, a figure-of-eight bandage around the rifle, a band and boot, tying it off on the sole of the foot, then he encircles the upper part of the chest with one belt and the hips with another, passing one around the rifle first when length permits. Two field dressings are next applied, the pad of the wound as far apart as possible, the short end of the bandage carried to the outer side and long end brought around under the thigh, around the rifle and then over and around both thighs being tied off to the short end, with the knot on the rifle. A pair of anklets buckled together placed around both legs just below the knees, then the pull-through cord is passed around the ankles and tied to give the anklets a firm grip on the legs.

Fractures of the Tibia and Fibula: Thirty-four cases of fracture of the shaft of the tibia and fibula are presented by Lincoln and Gordimer.<sup>324</sup> In 10 per cent of the cases the fracture was treated with Kirschner wire traction, in 28 per cent with plaster only and in 18 per cent by open reduction. The average age of the patients was 26 years, the average period of disability was 10 and seven-tenths months and the average stay in the hospital was sixty days. The objectives of treatment were the best possible end result and the shortest period of disability consistent with such a result. The authors were satisfied with their results and feel that the treatment of this rather common fracture has greatly improved within the last ten years. Data of the case histories are incorporated in a table. Medical and compensation claims influenced the period of disability.

Henderson<sup>325</sup> presents a case report in which a 26 year old soldier who suffered a compound fracture of the tibia in a motorcycle crash died thirty hours after operation. The clinical course was that of respiratory embarrassment. Autopsy showed the fracture to be in good alignment without vascular damage; the blood vessels of the brain, lungs and kidneys, however, contained many fat globules. Urinalysis before death revealed many fat globules in the urine, which

321. Caldwell, J. A.: Subtrochanteric Fractures of the Femur: An Operative Approach for Open Fixation, *Am. J. Surg.* 59:370-382 (Feb.) 1943.

322. Pique, J. A., and Valls, J. E.: Skeletal Traction or Whitman Method Using Plaster Cast in Lateral Fractures of Femoral Neck, *Rev. ortop. y traumatol.* 12:191-198 (Oct.) 1942.

323. Williams, P. L. W.: An Emergency Thigh Splint, *J. Roy. Army M. Corps* 79:310-311 (Dec.) 1942.

324. Lincoln, J. R., and Gordimer, H.: Fracture of Shafts of Both Bones of Lower Half of Leg, *Arch. Surg.* 46:697-704 (May) 1943.

325. Henderson, R. G.: Fat Embolism After Compound Fracture of Tibia, *Lancet* 1:297-298 (March) 1943.

proved to be animal fat. This was the only finding which gave a clue to the cause of the fatality.

Griesemer<sup>326</sup> reviews some of the methods that have been used in the management of fractures of the tibia and fibula under his supervision. The simple fracture with little or no displacement requires no reduction and is immobilized by anterior and posterior plaster splints for eight weeks. When weight bearing is allowed during the period of fixation, the nonpadded cast of Bohler is applied. The walking iron is used only for transverse fractures, because the author has seen a disturbance of position when it is used for spiral or oblique fractures. Fractures with displacement are reduced with local or general anesthesia, with the leg flexed to a right angle and placed in a Bohler frame with traction. The fragments are molded into place, checked with roentgenograms and immobilized in a nonpadded cast, which is kept on for eight weeks. Comminuted, spiral or oblique fractures require some form of skeletal traction. A steel pin or a Kirschner wire is placed through either the lower end of the tibia or the os calcis, and traction is instituted, followed by roentgenographic examination within thirty-six hours. If the position is satisfactory, a cast is applied and the wire incorporated in the plaster. Frequently the traction is continued until the cast is thoroughly dry. Overpull of the fragments must be avoided or may lead to delayed union or nonunion. If open reduction is required, this is usually done six or seven days following the injury. The original skeletal traction is maintained during the operation, and the author believes that stainless steel wire, if properly placed, effects satisfactory fixation and avoids the more extensive, time-consuming operation of plating. Sulfanilamide and fixation with plaster are used without fenestrating the cast. Compound fractures should be promptly debrided and reduced in six hours, with closure in certain cases. For those seen after six hours, débridement is not done; simple cleansing is the procedure, followed by the use of sulfanilamide and petrolatum gauze with plaster fixation. For nonunion, the sliding inlay graft of Albee has given the best results. The author and his associates have come to the conclusion that the most important factor in the treatment of these fractures is the skill of the surgeon rather than the particular method of management.

326. Griesemer, W. D.: Management of Fractures of Tibia and Fibula, *Pennsylvania M. J.* **46**:590-594 (March) 1943.

Shaar, Kreuz and Jones<sup>327</sup> discuss the use of the Stader splint for fractures of the tibia and fibula. A detailed discussion is given, including its application and use and the many errors in application. A group of clinical cases with excellent results is included. The authors recommend the use of the Stader splint for these fractures.

Silvis<sup>328</sup> gives a detailed description of how to make and use a Bohler frame. He prefers this type of frame to the Stader reduction splint, stating that it is simpler. His technic carefully follows that of Bohler.

Ronald<sup>329</sup> presents a short series of fractures of the tibia and fibula to demonstrate the advantages of operative fixation by means of a screw. The operation is performed seven to ten days after injury through a 4 inch (10 cm.) incision. The fracture is reduced and the ends of the bone held in a Hey Grove clamp. A vitallium screw of the correct length is then placed as nearly as possible at right angles to the line of fracture, so that it transfixes an equal thickness of bone in each fragment and engages the cortex of each fragment. Placing of the screw is more difficult in transverse fractures. In order to avoid subcutaneous projection of the head of the screw a V-notch is cut  $\frac{1}{4}$  inch (0.64 cm.) deep. The hole is drilled from the apex of the notch, which is then deepened sufficiently to accommodate the head of the screw. The screw is driven in. The stability of reduction is tested, the periosteum closed, the skin sutured and a padded plaster cast applied. With spiral fractures plaster fixation can usually be discarded in seven to nine weeks and weight bearing in plaster may be safe even earlier. Transverse and comminuted fractures are immobilized in plaster for eleven to twelve weeks. This technic was used for 12 fractures, 9 of which were spiral, 1 transverse and 2 comminuted. Union was sound in all cases, as shown by clinical and roentgen examination. The average time of union was several weeks less than that for tibial fractures treated by other methods. The instability of oblique and spiral fractures makes it necessary to prevent redisplacement either by internal fixation or by continuous traction. The advantages of internal fixation are that perfect apposition

327. Shaar, C. M.; Kreuz, F. P., Jr., and Jones, D. T.: Fractures of Tibia and Fibula: Treatment with Stader Reduction and Fixation Splint, *S. Clin. North America* **23**:599-630 (April) 1943.

328. Silvis, R. S.: Tibia Fractures: Treatment on Board Ship, *U. S. Nav. M. Bull.* **41**:331-338 (March) 1943.

329. Ronald, A.: Fixation of Oblique and Spiral Fractures of the Tibia by a Single Vitallium Screw, *Proc. Roy. Soc. Med.* **35**:763 (Oct.) 1942.



and excellent fixation are secured with a minimum of foreign material and that rapid union is promoted. The patient is ambulatory at an early date, and the period of immobilization in plaster is reduced. The only disadvantage is the danger of sepsis; under normal conditions this complication should not be encountered.

Fractures of the Ankle and Foot: Potvin<sup>330</sup> classifies fractures of the ankle as follows: (1) fractures of the mortise, including low fractures with and without displacement and no diastasis, median fractures with diastasis (Dupuytren) and high fractures (Maisonneuve); (2) fractures of the mortise and the tibial end, including fractures of the posterior and the anterior lip and fractures by tibial crushing. The mechanism of a fracture is in direct relation to secondary deformities discovered clinically and roentgenographically. It may be caused by external rotation, abduction, adduction or a fall.

Lee and Horan<sup>331</sup> discuss the internal fixation of fractures of the ankle. Certain injuries around the ankle do not give uniformly satisfactory results if treated by conservative methods. Consequently, the authors offer certain conditions which require open reduction and internal fixation and present a technic which has given excellent results: 1. Fracture of the lower end of the fibula when the fibular end is displaced outward and backward and the joint mortise is widened or when the fragment is serrated and precludes alinement by manipulation requires open reduction with internal fixation. The fragment is exposed, reduced and fixed with a long vitallium screw through the cortices of the fibula and tibia, and a plaster boot is applied. 2. Trimalleolar fracture in which the posterior tibial fragment includes a quarter or more of the tibial surface requires operative intervention. This fracture disrupts the gliding, weight-bearing surface of the tibia. The fragment is reduced by a Steinmann pin inserted into it posteriorly and a vitallium screw inserted anteriorly. 3. Fracture of the anterior tibial surface is usually comminuted and disrupts the tibial weight-bearing line. It is reduced by driving a Steinmann pin into the anterior fragment and fixed by a vitallium screw. 4. Fracture of the internal malleolus may result in nonunion if fibrous tissue is interposed. The fragment is easily reduced if exposed; it is then fixed to the tibia with chromic catgut. 5. Pott's fracture may be complicated by soft tissue between fragments or dislocation of the posterior tibial

tendon. This tendon is exposed, released from between the astragalus and the tibia and restored to its usual position. Other ligaments are repaired. 6. Separation of the tibia and fibula may result in widening of the joint mortise, with resultant pain and disability. Internal fixation with Kirschner wire equipped with thumb nuts for tightening is satisfactory. Traction is used if necessary. 7. Separation of the lower epiphysis of the fibula with backward displacement and interposition of a bone spicule requires open reduction. 8. Recurrent dislocation of the peroneal tendons is accompanied by a jarring snap and pain. The ligament may be lax, the groove for the tendon too narrow or a supernumerary tendon may exist. Repair is done by anchoring the tendons and reinforcing them. Plaster fixation is used after all of these procedures.

Moritz<sup>332</sup> presents an interesting account of ski injuries. In the three years before May 1942, there were at Sun Valley, Idaho: 257 fractures, 35 dislocations, 762 sprains, 147 contusions, 57 abrasions and 114 lacerations. A ski patrol constantly on duty administered first aid and transported the casualties to the medical department. One hundred and eighty-seven of the 257 fractures (or 72 per cent) involved bones of the lower extremity. Practically all of these were due to torsion strains and rotation of the leg in falling. The most common fracture was a long spiral break in the tibia. Injuries of the foot were relatively infrequent. While there were 270 injuries to the knee, the semilunar cartilages were damaged in only 7 of these. The types of ski binding now used are much tighter than before and do not permit the foot to become disengaged in falls. They make for better control of the skis and greater skill in racing but are obviously to blame for the increased number of injuries of the knee and ankle. It is questionable whether ski troops should use such dangerous bindings.

For isolated fractures of the internal malleolus, Meekison<sup>333</sup> favors open reduction and screw fixation. He states that "since the introduction of vitallium this has been the metal of choice." In air crew personnel this method has favored early return to duty. In a group of 235 fractures of the ankle, 23 were fractures of the internal malleolus and 11 produced diastasis of the tibio-fibular joint. The fractures of the internal malleolus were explored through an incision directly over the fracture, the fragment was replaced and a vitallium screw was inserted. The head of the screw was buried under the internal collateral

330. Potvin, P.: *Anatomy of Instep: Classification and Mechanism of Fractures*, Union méd. du Canada 72:121-124 (Feb.) 1943.

331. Lee, H. C., and Horan, T. B.: *Internal Fixation in Injuries of Ankle*, Surg., Gynec. & Obst. 76:593-599 (May) 1943.

332. Moritz, J. R.: *Ski Injuries: A Statistical and Analytic Study*, J. A. M. A. 121:97-99 (Jan. 9) 1942.

333. Meekison, D. M.: *Fracture of Internal Malleolus and Diastasis Inferior of Tibio-Fibular Joint*, Proc. Roy. Soc. Med. 35:761-762 (Oct.) 1942.

ligament. When there was fracture of the fibula and diastasis, a vitallium plate was applied to the fibula and one long screw was passed through the plate and fibula and into the tibia. Diastasis alone was treated by passing one screw through the fibula into the tibia. If the original roentgenogram showed no fracture, one view was taken with the foot in inversion and another with the foot in eversion. These demonstrated the abnormal motion in the mortise of the ankle. A padded cast was applied postoperatively for ten to fourteen days; it was then changed for a nonpadded cast with a walking heel of Sorbo rubber. After six to seven weeks a Viscopaste bandage was applied for another week or more. [ED. NOTE (W. G. S.).—Often perfect reduction of isolated fractures of the internal malleolus can be obtained by strong traction on the foot to the inner side and application of a cast with the foot inverted. Nevertheless, open reduction and screw fixation may hasten recovery and requires less postoperative fixation with a cast.]

Bierman<sup>334</sup> emphasizes the importance of an additional roentgenographic view to demonstrate chip fracture, which is often associated with severe sprain of the ankle. With the severe sprain, there is complete or nearly complete tearing of the middle or anterior or both ligamentous bands, and with a tearing of the middle band a thin fragment of bone is often avulsed. For demonstration of the chip fracture, in addition to the usual anterior and lateral views, the patient lies prone on the table and a sandbag is so placed that the anterior surface of the ankle rests on it. A cardboard film holder is placed between the ankle and the sandbag so that the lower end of the holder extends about 1 cm. beyond the great toe. The foot is held in plantar flexion; the x-ray tube is tilted toward the head, and the central ray is directed toward the dorsum of the foot and at a right angle to it, so that it will penetrate between the detached small fragments and the shaft. For severe sprains, this technic should be used, and if a chip fracture is demonstrated a period of immobilization of six weeks is required. Subluxation of the ankle may be demonstrated by taking roentgenograms of the ankle in eversion. [ED. NOTE (J. J. F.).—This is a valuable article because it emphasizes a technic that is ordinarily not employed and that gives valuable information from the standpoint of diagnosis and treatment.]

Gillette<sup>335</sup> finds the number of poor or only fair end results in certain types of fractures of the ankle great. The tendency to treat them by

closed reduction is largely responsible. He recommends open reduction and internal fixation if closed methods have not produced accurate replacement. Inaccurate reduction is responsible for the disabling condition of traumatic arthritis. There are four main types of fractures involving the ankle. The eversion type involves the lower end of the fibula with or without rupture of the deltoid ligament. Osteotomy of the fibula and fixation usually suffice. If malunion has existed for a considerable period, it is necessary usually to excise the fibrous tissue between the tibia and the astragalus. Supramalleolar osteotomy may be necessary. If fresh fractures of the fibula are fixed early, when there is a tendency to displacement, major procedures can be avoided. In certain cases of Pott's fracture, it may be necessary to fix the fibula and in addition the internal malleolus if displacement persists. For malunion supramalleolar osteotomy may be necessary, and arthrodesis may be indicated for traumatic arthritis. For the third type, which is the Cotton fracture, open reduction of the posterior malleolus should be done. It may be necessary also to fix internally one or both of the other malleoli. With the fourth type, anterior dislocation with fracture of the anterior margin of the tibia, a nail should be inserted through an anterior incision. If normal function cannot be obtained, fixation of the tibioastragalar joint should be done. When a fusion is done, any malalignment should be corrected by osteotomy before the joint is fixed. [ED. NOTE (J. J. F.).—The majority of fractures of the ankle respond favorably to conservative treatment. Open reduction should be reserved for the fractures with which this method fails to effect reduction.]

Allredge<sup>336</sup> presents a three year study of 56 cases of injury to the ankle which required hospitalization. He points out the mechanism which causes certain types of fractures. He believes that the ligamentous injury is as important in some cases as the fracture itself. In 29 of the 56 cases the fracture of the ankle was an external rotation fracture, in 21 it was an abduction fracture and in 6 it was an adduction fracture. In 29 of the 56 cases, closed reduction was the treatment employed and in 27 open reduction and metal fixation of one type or another were used. It is apparent that absolute anatomic approximation is necessary and should be maintained throughout the course of treatment until bony union is complete. [ED. NOTE (J. J. F.).—If only the patients with serious fractures were hospitalized, the incidence of open reduction might not be too high.]

334. Bierman, M. I.: Avulsion Fracture of Fibula, U. S. Nav. M. Bull. 41:647-652 (May) 1943.

335. Gillette, E. P.: Fractures About the Ankle, Indust. Med. 12:160 (March) 1943.

336. Allredge, R. H.: Fractures About the Ankle Joint, New Orleans M. & S. J. 95:414-423 (March) 1943.

Tobin<sup>337</sup> tags another fracture. "Fracture of the posterior articular margin or 'posterior lip' of the tibia" he designates as a paratrooper's fracture. There is little or no displacement of the fragment, probably because of the support of the tight boot. The treatment consists of immobilization of the joint for four weeks in a skin-tight plaster cast with a walking iron. Full return to duty is expected in three or more months.

Shaar and Kreuz<sup>338</sup> discuss the use of the Stader splint for fractures of the os calcis. In their opinion the Bohler method is too complicated for the ordinary surgeon, and they feel that the Stader splint is simpler and gives better control of the fragments and may shorten the period of convalescence. There is a rather complete discussion of the anatomy, diagnosis, roentgen findings and prognosis of these fractures. [Ed. NOTE (D. H. O.).—It is interesting to note that these authors feel that the Stader splint is simpler than the Bohler, while others consider the opposite to be true. Each surgeon uses the method with which he is most familiar.]

Rogers<sup>339</sup> discusses at some length fracture of the os calcis produced by a force directed from below, such as the buckling of the deck of a ship. He gives a comprehensive review of the anatomy and discusses the proper roentgenograms to expose the fracture. He recommends the use of the Bohler method with traction on a frame followed by application of a cast. He expresses his preference for this type of fixation over external skeletal fixation with a Stader or similar splint.

Blair<sup>340</sup> describes a new operation for fractures of the astragalus and reports 2 cases. In 1 case there was a fracture-dislocation of the body of the astragalus, and in the other a comminuted neck and head remained in normal position. Through an anterolateral incision, a sliding bone graft was embedded from the tibia to the neck of the astragalus. The results in both cases were good. The author believes that with this operation weight bearing occurs on a normal, undisturbed joint and that there is less tendency to subsequent deformity. He is convinced that this procedure is better than astragalectomy or any other procedure of arthrodesis about the ankle.

Fractures of the os calcis which involve astragalocalcaneal joint often cause late and severe disability. The usual treatment this complication is subastragalar arthrodesis. The standard types of operation are so formidable and require such painstaking care that they not always succeed. Gallie<sup>341</sup> describes a simple operation in which through a posterior incision the subastragalar joint is exposed and is fused by wedging a square tibial graft into a square hole cut across the joint. Of 50 operations which the author has performed in the past years, all but 7 resulted in solid bony union. This is a simple, rapid method for obtaining astragalocalcaneal fusion.

Creer<sup>342</sup> maintains that in many cases of fracture of the os calcis the midtarsal joint undamaged and that arthrodesis between the astragalus and the os calcis is sufficient to relieve the pain. He describes a method whereby the joint is fused by the insertion of a small graft. [Ed. NOTE (W. G. S.).—I doubt if it is possible to tell from the roentgenograms whether the midtarsal joint is undamaged or not. It is common experience to find on exploration that all the articular surfaces of the calcaneus are crushed and distorted, whether this is demonstrated in the roentgenogram or not.]

Fractures of the os calcis which cause crushing of the articular surfaces of the astragalus and the os calcis result in painful arthritis no matter how well the gross displacement is corrected. According to Watson-Jones, the posterior portion of the astragalocalcaneal joint is involved in 45 per cent of all fractures of the os calcis. Armstrong<sup>343</sup> describes an operation which he has devised and which produces a mechanically stable arthrodesis allowing essential early weight bearing. Through a lateral incision the posterior subastragalar joint is exposed and denuded of cartilage. Through an anterior incision over the neck of the astragalus, holes are drilled through the neck and the posterior subastragalar joint and into the calcaneus. A tibial graft  $4\frac{1}{2}$  inches (11 cm.) long is driven into the hole and into the calcaneus. After two weeks the patient is able to bear weight in a walking cast, and solid fusion is obtained in nine weeks. [Ed. NOTE (W. G. S.).—The author includes pictures showing excellent fusion of the subastragalar joint in nine weeks. However, this is a far from simple operation and can be accomplished

337. Tobin, W. J.: Paratrooper Fracture, *Arch. Surg.* 46:780-783 (May) 1943.

338. Shaar, C. M., and Kreuz, F. P., Jr.: Treatment of Fractures of Os Calcis: Presentation of New Method, *S. Clin. North America* 23:291-308 (Feb.) 1943.

339. Rogers, W. L.: Os Calcis Fractures in Naval Warfare, *U. S. Nav. M. Bull.* 41:324-330 (March) 1943.

340. Blair, H. C.: Comminuted Fractures and Fracture Dislocations of the Body of the Astragalus, *Am. J. Surg.* 59:37-43 (Jan.) 1943.

341. Gallie, W. E.: Subastragalar Arthrodesis Fractures of the Os Calcis, *J. Bone & Joint Surg.* 2: 731-736 (Oct.) 1943.

342. Creer, W. S.: Modified Subtaloid Arthrodesis, *Proc. Roy. Soc. Med.* 36:333-334 (May) 1943.

343. Armstrong, J. R.: Posterior Subastragalar Arthrodesis in Fractured Os Calcis, *Lancet* 2:505-506 (Oct. 23) 1943.

only with careful roentgenograms taken at each stage of the procedure.]

Metz, Householder and DePree<sup>344</sup> recommend large pressure tongs 3 feet (90 cm.) long with felt-padded blades for the compression of fractures of the os calcis or of the upper end of the tibia. [ED. NOTE (W. G. S.).—This appears to be an improvement over Bohler's clamps or the machinist clamps or the C clamps, which have been commonly used. The tongs are probably easier to control, and the amount of force can be more directly determined than with any of the screw type clamps.]

According to Hauser,<sup>345</sup> fractures of the os calcis have occurred frequently in the present war; they cause a great deal of disability and do not respond well to treatment. Preliminary treatment is directed toward shock and lacerations and is followed by reduction and fixation and establishment of normal function of the foot. A local or general anesthetic is used, with the knee in flexion and the foot in plantar flexion. A Bohler compress may be used and the os calcis reduced manually. Plaster fixation is then utilized until union occurs. Statistics indicate that the disability may vary from 10 to 80 per cent for the injured limb. The author believes that the disability usually results from pain in the heel and that this pain is associated with spasm of the peroneal muscle and valgus deformity of the heel as well as loss of the longitudinal arch; most surgeons, however, consider the pain to be a result of a fracture into the joint, with arthritis and muscular spasm as a sequence. Consequently, the author believes that if the heel is placed in varus and the anterior part of the foot is in pronation normal function without pain will result. Triple arthrodesis, therefore, will seldom be necessary.

Rosa Ribeiro<sup>346</sup> draws attention to the low incidence of fracture of the posterior superior tuberosity of the os calcis, describing the first case to be reported in his country. Studies on the cadaver are described, explaining the mechanism of the fracture. After a study of symptoms, the author discusses the treatment, which consists of early open intervention, osteosynthesis with absorbable material and immobilization in plaster with the foot in equinus. The result was excellent, without postoperative complication of any kind. These fractures lead to

forced extension of the achilles tendon and the triceps muscle, with resulting contracture of the musculature.

For multiple fractures of the metatarsal shafts, Marrin<sup>347</sup> demonstrates a method of inserting wires longitudinally through the medulla of the bones. This provides excellent immobilization with the bones in perfect position during the time of healing of the fractures.

*War Wounds and Compound Fractures.*—Toffelmier<sup>348</sup> reports that in the South Pacific it was found that for transportation of a wounded person a plaster cast was the most successful method of immobilizing a compound fracture. Compound fractures of the femur were treated with a plaster of paris spica with a pin near the knee. Compound fractures of the tibia were supported by means of a full length cast with a pin through the heel. Compound fractures of the humerus were treated with a hanging cast. Surprisingly, most of the men reached hospitals on the mainland with little angulation or deformity.

Of the wounded men on the Eastern Front cared for by Hundemer,<sup>349</sup> 56.37 per cent had injuries of the limbs, and of these 14.91 per cent had wounds of the joints. Fifty-nine per cent of these injuries were in the knee, and about 90 per cent of all injuries of the joints included moderate to severe damage to bone. Emergency treatment for through and through injuries of the joints consisted of sterile dressing, aspiration and immobilization. Open injuries of the joint were transformed into closed ones if seen within sixty hours. Excision, suturing of the capsule and rubber drainage were used. Local chemotherapy did not seem to influence the course of healing. Primary resection of the joint was rarely used, but partial resection (femoral condyle, patella, etc.) was employed. Comminuted fractures into the joint with extensive damage of vessels and nerves call for primary amputation. Foreign bodies should be removed within forty-eight hours. After that they are treated expectantly. Immobilization in plaster of paris should be early and adequate. A spica for the hip is necessary for injuries of the knee joint.

344. Metz, A. R.; Householder, R., and DePree, J. F.: Impaction of Fractures by Large Pressure Tongs, *Am. J. Surg.* 59:447-449 (Feb.) 1943.

345. Hauser, E. D. W.: Fractures of the Calcaneus: Treatment of Altered Statics, *Physiotherapy Rev.* 23: 51-54 (March) 1943.

346. Rosa Ribeiro, E.: Calcaneum Fractures of Posterosuperior Tuberosity: Experimental Study, *Rev. méd. munic.* 4:165-182 (Aug.) 1942.

347. Marrin, M. M.: Multiple Metatarsal Fractures: A Method of Fixation, *Mil. Surgeon* 93:81-83 (July) 1943.

348. Toffelmier, D. D.: Experiences with Compound Fractures from the Pacific Combat Area with Presentation of New Appliances for the Care of the War Injured, *Bull. Am. Coll. Surgeons* 28:132-133 (June) 1943.

349. Hundemer, W.: Military Experience with Joint Wounds, *Bull. War Med.* 3:268-270 (Jan.) 1943.

extent by use of sulfonamide drugs. The author has not been convinced that local application of sulfonamide compounds is of any value. Closure should be done loosely and never by layers. Relaxing incisions are used when tension is increased. All patients receive combined tetanus and *Bacillus perfringens* antitoxin and sulfadiazine by mouth. If streptococci predominate in the wound, sulfanilamide is used. [ED. NOTE (J. J. F.).—Local application of one of the sulfonamide drugs in addition to oral administration seems to be indicated at the present time.]

Davis and Fortune<sup>360</sup> describe the management of compound fractures in considerable detail. Attention should be paid to hemoconcentration, blood count and blood pressure on the patient's arrival at the hospital. The authors emphasize the importance of careful cleansing of the wound with soap and water and saline solution and of adequate débridement. Vitallium plates and screws are used for fixation, and sulfanilamide is placed in the wound. The wound is closed with clips, silk or chromic catgut sutures. In some cases it is necessary to undermine flaps of skin or use a split or full thickness graft in order to close the wound. A compression dressing is used and not disturbed for ten days. Prophylactic gas gangrene and tetanus antiserum are given. The authors report a series of 50 compound fractures. Forty-three healed by primary intention. There were no cases of nonunion, gas gangrene or amputation due to infection. Five of the 7 patients whose wounds broke down are now working, and none of them had serious results. A revision of the method of treatment of compound fractures based on advances in other fields gives fewer amputations, a reduction in sepsis and a decrease in the number of delayed unions and nonunions. The use of sulfonamide compounds has added significantly to the safety of primary closure and to the effectiveness of the open method.

Observation of compound fractures infected with *Staph. pyogenes* and treated with sulapyridine and sulfathiazole in addition to standard antiseptic and surgical measures was made by Heggie, Kendall and Heggie.<sup>361</sup> They conclude that sulfathiazole is more efficacious than sulapyridine in the treatment of compound fractures that have become infected with *Staph. pyogenes*. The necessity for chemotherapy before and after operation is stressed, as is also the combination

of local and oral administration. For local application of a sulfonamide compound does give adequate bacteriostatic concentration, cause of cellular debris, tissues with low water content and resultant low solubility and concentration of the drug. No staphylococci which were resistant to sulfonamide drugs were encountered in this series of cases.

Because a mixture consisting of carbamide (urea) 85 per cent, sulfanilamide 13 per cent and sulfathiazole 2 per cent is relatively harmless to normal tissue, hastens healing, eliminates odor from infected wounds, is bactericidal and dissolves dead tissue, Ilfeld<sup>362</sup> favors its use in traumatic wounds. If carbamide is used, the author believes that primary closure of compound wounds may be done many hours after the injury even though six hours is usually considered the dividing line. The method of treatment consists of scrubbing with soap and water, irrigation first with isotonic solution of sodium chloride and then with 500 cc. of saturated solution of a mixture of carbamide and sulfanilamide in sterile water, débridement and a second irrigation with saline solution and the carbamide-sulfanilamide mixture. The injury is repaired, and carbamide-sulfanilamide powder is sprinkled in all parts of the wound, which is then closed with primary sutures. In the cases presented, excellent results were obtained. The author states that this mixture, as well as any of the sulfonamide drugs, delays healing and retards epithelization somewhat. Urea accelerates the formation of granulation tissue; consequently at the stage of epithelization the necessity for the use of the carbamide-sulfanilamide mixture has passed. Because of the action of urea, the author feels that the urea-sulfanilamide mixture is superior to a sulfonamide compound alone in the treatment of traumatic wounds.

The results of treating 245 compound fractures of the tibia and fibula are given by Griswold.<sup>363</sup> The surgical principles which he emphasizes are (1) removing or rendering innocuous the bacteria in the wound without causing additional injury; (2) removing foreign bodies and dead tissue which provide food and protection for the bacteria, and (3) providing rest and protection from tension, trauma and reinfection, so that reparative processes may not be hindered. The objects are accomplished by careful preliminary treatment of the wounds, irrigation and closure.

360. Davis, A. G., and Fortune, C. W.: Compound Fractures, *J. Bone & Joint Surg.* 25:97-120 (Jan.) 1943.

361. Heggie, J. F.; Kendall, A. W., and Heggie, R. M.: Infected Wounds Involving Bone Treated with Sulphapyridine and Sulphathiazole. *Brit. M. J.* 2:655-658 (Dec. 5) 1942.

362. Ilfeld, F. W.: Carbamide Sulfonamide Mixture: Use in Treatment of Compound Fractures and Traumatic Wounds, *Surg., Gynec. & Obst.* 76:427-428 (April) 1943.

363. Griswold, R. A.: Treatment of the Wound in Compound Fractures, *J. Indiana M. A.* 36:55-59 (Feb.) 1943.

without tension or petrolatum packing if closure not used. Sulfonamide compounds complement surgical treatment. The author emphasizes that compound wounds should be treated as carefully as any elective surgical condition.

Koch<sup>364</sup> emphasizes the contributions of Thomas, Orr, Reid and Blair to the treatment of wounds and compound injuries. Since he believes that wounds of the parietes and the extremities are treated by the same principles as all other wounds, he offers eight primary considerations. The first is the arrest of hemorrhage and the treatment of shock. Elevation if possible and application of a sterile pressure dressing in the correct place are the important points mentioned by him. Next are the prevention of additional contamination and trauma, the use of masks, sterile instruments and dressings, the avoidance of strong antiseptics and the avoidance of probing the open wound—all tend to prevent external infection. The diagnosis of the extent of the injury is then made with a search for the presence of multiple injuries. It is important to determine the entrance and exit of metal fragments and also to consider in turn the blood vessels, bones, nerves and tendons. The pulse rate, the roentgenogram and the motor and sensory status of the extremity will usually indicate the diagnosis. The contaminated wound is then converted into a clean wound by first washing around the injured area with plain soap and water and then irrigating with copious amounts of sterile saline solution. The wound itself is then cleansed in the same way. The author has had excellent results when he has used this simple method for all open wounds. The foreign material and the devitalized tissue are then excised, the latter being recognized by its color, its failure to bleed and the amount of contusion. As much viable skin and fragmented bone as possible should be saved. The injured structures are then repaired, and the method of closure will depend on the character of the first aid treatment and the time that has elapsed following the injury, as well as the character and extent of the wound. Specific mention is made of injuries with loss of covering tissue, injuries of blood vessels, injuries of bones and joints and injuries of nerves and tendons. For the loss of covering tissues, early application of skin grafts gives the best chance for a satisfactory recovery. The details involved have been stressed by Blair, Brown and Byars, by Davis and by others. Koch emphasizes that closure of the open wound and healing in the minimum time are the objectives. When blood vessels are in-

jured and a foreign body is involved, the author believes that it is wise to expose the area by an adequate incision above and below the foreign body before attempting its removal. With injury of bones and joints, adequate cleansing is followed by reduction and immobilization. The author points out that the exact type of metal or retaining device employed for internal fixation is secondary in importance to the freedom from infection and the healing by primary union. Koch mentions that in order to secure reduction and immobilization of a comminuted or oblique fracture with the aid of pins and distraction apparatus one must have both considerable equipment and adequate training in its use. When nerves and tendons are injured, the tendons should be repaired first because they lie more deeply and because there should be a minimum of manipulation after the delicate nerves are repaired. Best results are secured if the wound heals by primary union and if postoperative relaxation of the injured structures is maintained for from three to four weeks. Adequate immobilization in a position of minimum tension plus moderate uniform compression over the area of the wound is important in the treatment of fractured tendons, nerves and soft tissues as well as bones. The author believes that the essential factors in the success of Orr and Trueta's method are continued and uninterrupted rest with moderate pressure and freedom from repeated bacterial contamination. The last important principle is clean surgical care, which involves a masked mouth and nose, clean hands, clean instruments and "forks, not fingers." Several illustrations of injuries which have been treated by this method are included in the article, and the excellent results are evident.

The care of wounds under emergency conditions is also discussed by Koch,<sup>365</sup> and a description and diagram of an emergency unit are presented. The author mentions chemotherapy and its use for infected wounds. The occurrence of unusual infections such as gas gangrene, chronic undermining ulcers and bacterially synergistic gangrene is discussed and their treatment described. The author makes a slight commentary on burns, repeating that they are large open wounds which require the same principles of treatment that have been stressed for the general treatment of wounds.

*Fatigue Fractures, March Fractures and Stress Fractures.*—With the vast expansion of armies everywhere, the phenomena of fatigue and the resulting effects on the skeletal system are

364. Koch, S. L.: *Injuries of the Parietes and Extremities*, Surg., Gynec. & Obst. 76:1-22 (Jan.) 1943.

365. Koch, S. L.: *Injuries of the Parietes and Extremities: Care of Wounds Under Emergency Conditions*, Surg., Gynec. & Obst. 76:189-196 (Feb.) 1943.

brought to the forefront. Peaceful people rarely observe these manifestations, which in the past have become known principally from the literature of the goose-stepping Fatherland.

Hartley<sup>366</sup> discusses fatigue fractures in general terms. Since march fracture was first described in 1855 there have been few reports of fatigue fractures in bones other than the upper third of the tibia, especially in England and America—the two greatest nonmilitary countries. On the other hand, one report showed that in Germany in 1936 there were 590 fatigue fractures, with 70 in the tibia, 13 in the femur, 12 in the fibula, 4 in the os calcis and 3 in the pelvis. Now, with England and America training huge armies, these "stress fractures" are becoming increasingly common. Stress, insufficiency or fatigue fractures occur in apparently normal bone and cause pain on weight bearing. The crack in the bone may be invisible in the roentgenogram but is detected by the formation of subperiosteal callus. Recognition of this condition in the bones of the lower extremity is essential when one is considering vague accumulations of bone that may be confused with formation of tumor, osteitis or osteomyelitis.

Blumenfeld<sup>367</sup> reports a case of spontaneous fracture in the lower third of the tibial shaft in a 23 year old soldier. The patient had been in the army nine months and had been a cook but had taken no part in the drills, athletics or hiking. The fracture line was never complete but more nearly resembled a fissure fracture. Symptoms subsided rapidly when weight bearing was discontinued.

Bush<sup>368</sup> reports a large series of march fractures. March foot is a progressive lesion if not treated early. The patient has a history of acute pain in the anterior portion of the foot while marching a long distance; dorsal swelling and ecchymosis appear over the midmetatarsal region; there is a palpable mass over the involved bone, and sharply localized tenderness is present. In some cases these signs are present without roentgenographic evidence of fracture; in others there is evidence of subperiosteal callus, and finally in some a fracture line can be clearly demonstrated. Predisposing causes are an abnormally elongated second metatarsal shaft, short shoes and extra stress. Treatment by strapping is successful if there is no frank fracture; other-

wise, a cast for three weeks is advisable. 100 march fractures seen, the third metatarsal bone was involved in 72 and the second metatarsal bone in 25.

Flavell<sup>369</sup> reports 15 cases of march fracture among 4,000 members of the Royal Air Force seen in three months at his clinic. A shoe with an abducted first metatarsal shaft was the common cause of the undue strain thrown on the second and the third metatarsal shaft. In one case was there preexisting metatarsalgia. There was no persistent pain after healing of the fractures. [Ed. Note (W. G. S.).—Once again the point is made that march fracture is increasingly common in the personnel of the Air Forces, which are now extremely populous.]

Ingersoll<sup>370</sup> states that march fracture and other fatigue fractures seem to result from fatigue of the muscles, tendons and ligaments. However, "ice skater's fracture" of the lower third of the fibula suggests fatigue of bone as a strain causes the cracks which appear in repeatedly stressed metal. Since bone is a living tissue the usual reparative reactions take place simultaneously, and subperiosteal new bone is formed at the site of the fatigue fracture. Three of these fractures occurred in boys who had received ice skates for Christmas and who were skating for the first time. The author believes that there is much strain on the foot in even the best skating and that this becomes more marked with fatigue. Strain on the fibula is produced by a slight rotation of the astragalus, and the fibula cracks at its weakest point, 2 to 3 inches (5.1 to 7.6 cm.) above its distal point. [Ed. Note (W. G. S.).—This is an interesting type of fracture and is brought up in current reports on various types of fatigue fractures in the Army.]

Barns<sup>371</sup> reports on 20 march fractures which were seen in a Royal Air Force training station in a few months. All the patients were men in the best physical condition. Pain and limp were the chief symptoms. The author points out that the first roentgenographic evidence of damage to the metatarsal shaft is apparent on the dorsomedial aspect of the bone.

Berkman<sup>372</sup> studied 15 cases of march fracture. In 14 cases the distal third of the second metatarsal bone was involved.

369. Flavell, G.: March Fracture, *Lancet* 2:66 (July 17) 1943.

370. Ingersoll, C. F.: Ice Skater's Fracture: Form of Fatigue Fracture, *Am. J. Roentgenol.* 50:499-504 (Oct.) 1943.

371. Barns, H. H. F.: March Fracture of the Metatarsal Bones, *Brit. M. J.* 2:608-609 (Nov. 13) 1943.

372. Berkman, E.: Etiologic Possibilities of March Fractures, *J. Bone & Joint Surg.* 25:206-207 (Jan.) 1943.

366. Hartley, J. B.: "Stress" or "Fatigue" Fractures of Bone, *Brit. J. Radiol.* 16:255-262 (Sept.) 1943.

367. Blumenfeld, E.: March Fracture of the Tibia, *J. Bone & Joint Surg.* 25:921-924 (Oct.) 1943.

368. Bush, L. F.: March Foot: Its Early Diagnosis and Treatment, *Army M. Bull.*, July 1943, no. 68, pp. 126-134.



ird metatarsals was involved. In 13 cases e fractures occurred in new recruits, who had ot been inducted over three weeks. Pain, lameness and swelling developed during the march or within ten to twenty-four hours. In all cases army shoes that were stiff and rigid were worn, and some loss of voluntary dorsiflexion was evident. Long hikes and stiff army shoes, preventing the proper take-off, produce a strain on the metatarsal heads predisposing to this type of fracture. The increased length of the second and third metatarsal bones and the added weight which they bear offer some evidence as to why the fracture so frequently involves these bones.

Sweet and Kisner,<sup>373</sup> from the American military medical service, discuss the cause, diagnosis, symptoms and treatment of march foot. Three rather typical case reports are included. Recommended treatment consists of immobilization in plaster for four to eight weeks followed by active physical therapy for another two to three weeks.

Swart<sup>374</sup> calls attention to the fact that the pregnant woman provides almost ideally the circumstances which predispose to march fracture. He points out, however, that he was unable to find any case in the English literature in which the condition was found in a pregnant woman; he reports a case of march foot in a woman seven months pregnant. He recommends fixation in plaster, with the use of a walking iron cast after a few days.

*Healing of Fractures.*—Vance and Wyatt<sup>375</sup> present a comprehensive discussion of the healing of fractures in those locations in which there is no external callus. They discuss the method of healing of ordinary fractures, dividing it into stages, as follows: (1) hemorrhage in and about the fracture, (2) decalcification and resorption of devitalized bone, (3) ingrowth of granulation tissue about the fracture, (4) formation of osseous and cartilaginous matrix, (5) calcification and organization of matrix to form bony union and (6) shaping of the new bone to its final contour. They discuss at some length the criterion for determining nonunion in the absence of external callus and emphasize the fact that there is no standard time for healing of fractures.

[Ed. NOTE (D. H. O.).—This is a worth while article concerning a subject of extreme importance, which has been neglected. The authors

go into detail, and this article merits careful study.]

Solandt, Partridge and Hunter,<sup>376</sup> by experimental work on rats, attempted to determine the effect of muscular sensitivity caused by skeletal fixation of the joint. They noted that in the early stages of skeletal fixation, the atrophy and hypersensitivity to acetylcholine were similar to such reactions caused by loss of nerve supply but that the extent of reaction was much less. [Ed. NOTE (D. H. O.).—This is an interesting subject for experimentation, but much remains to be done before any conclusion can be drawn.]

In an attempt to determine the comparative rates of absorption and callus-stimulating properties of autogenous bone, beef bone, ivory and cow horn, Hughes<sup>377</sup> performed a series of experiments in which the various materials were implanted in femurs of dogs and rabbits. Roentgen and microscopic studies were made and the results tabulated. It was decided that substances located within the medullary canal were absorbed more rapidly than those within the cortex; substances which were extracortical were absorbed most rapidly. Absorption of the extracortical portion of autogenous and beef bone pegs was perceptible after one month. Absorption of ivory pegs was seen after six months and of cow horn pegs after nine months. Autogenous and beef bone pegs showed microscopic evidence of union with the host bone, whereas ivory and cow horn pegs did not. It was concluded that beef bone is a much better substitute for autogenous bone grafts than ivory or cow horn.

Krockert<sup>378</sup> reports on research on the influence of vitamins on the healing of bone. Rabbits in which the right forelegs had been broken were given as a supplement to the standard daily diet vitamins A, B, C and D. Roentgenograms were made on the fourth, thirteenth and twenty-first day after operation. Vitamin A seemed to have no beneficial effect on the healing process and perhaps even delayed the formation of callus. Vitamins B and C had a favorable effect on consolidation of the fracture and on

376. Solandt, D. Y.; Partridge, R. C., and Hunter, J.: Effect of Skeletal Fixation on Skeletal Muscle, *J. Neurophysiol.* 6:17-22 (Jan.) 1943.

377. Hughes, C. W.: Rate of Absorption and Callus Stimulating Properties of Cow Horn, Ivory, Beef Bone and Autogenous Bone, *Surg., Gynec. & Obst.* 76:655-671 (June) 1943.

373. Sweet, H. E., and Kisner, W. K.: March Fractures, *J. Bone and Joint Surg.* 25:188-192 (Jan.) 1943.  
374. Swart, H. A.: March Fracture as Complication of Pregnancy, *Am. J. Surg.* 59:602-604 (March) 1943.  
375. Vance, R. G., and Wyatt, G. M.: Roentgenologic Manifestations of Bone Repair: Healing of Fractures Without External Callus, *Am. J. Surg.* 59:404-408 (Feb.) 1943.

378. Krockert, G.: Is It Possible to Observe on Skiagraphs of Healing Fractures Increased Deposition of Minerals as a Result of Vitamin Therapy? *Deutsche Ztschr. f. Chir.* 255:398, 1942; abstracted, *Bull. War Med* 3:267 (Jan.) 1943.



the deposition of minerals. The results obtained with vitamin D were not consistent.

*Injuries to Joints.*—Griffiths<sup>379</sup> discusses rehabilitation after injuries of joints. The joint should be considered an integral part of the whole body, and then a decision should be made concerning how the injury has interfered with working capacity. The disability may be due to loss of movement, loss of stability, loss of sense in the joint or increased pain; each leads to a loss of power. After anatomic reconstruction of the joint, immobilization is secured until primary repair of damaged tissue occurs. During this rest, steps should be taken to insure good circulation of the blood and lymph. The author believes that more stiff joints are due to inadequate return of venous blood than to any other cause. Muscular action is the one great factor which helps maintain return of venous blood, and this may be provided despite the presence of a plaster cast by retaining the tonus of the muscles on both sides of the joint. Massage, faradism and other physical therapy methods are important but subordinate to carefully selected active exercises for the muscles. Activity of the rest of the body is also important. Fear, pain and boredom cause early fatigue, and the exercises chosen should allay all of these obstacles. Light exercises in the gymnasium, physical therapy, games and occupational therapy all prove helpful. In some cases assisted movements are used in which the force of gravity is eliminated, i. e. exercises in the swimming pool or on the ground. When the working capacity of the patient has returned, only harm is done by continuing special therapy.

Pugh<sup>380</sup> advises open reduction and fixation with a wire or nail for trimalleolar fractures of the ankle. [ED. NOTE (W. G. S.).—This may be necessary for old fractures, but with fresh fractures the fragments can be replaced by traction and manipulation of the foot into dorsiflexion.] For fractures of the carpal scaphoid, skin-tight plaster fixation for four to five months is advised. For uncomplicated injuries of the joints, traction and early motion are recommended, to prevent late arthritic changes.

In a discussion of the treatment of compound injuries of bones and joints, Dickson<sup>381</sup> states that the first objective should be to convert the compound fracture into a closed fracture as rapidly as possible, the best possible alinement of

the ends of the bone being maintained in the meantime. With old infected compound fractures, the main objectives are to overcome the infection and preserve the position of the bone in anticipation of a subsequent bone graft.

*General Treatment of Fractures.*—The regular annual report<sup>382</sup> of the fracture service at the Mayo Clinic for 1942 shows that 1,017 fractures were seen, 500 fresh fractures and 517 old fractures. Only 86 operations were performed in the entire group of fresh fractures. In the group of old fractures, 79 operations were carried out. The mortality rate was the same as in five previous annual studies of the experience of the Mayo Clinic.

Stuck and Venable<sup>383</sup> review the history of their introduction of vitallium into the field of internal fixation and list some of the many different applications of this alloy, not only in the treatment of fractures but in the replacement of tissue, such as vitallium cups for arthroplasty, replacement of the upper end of the femur with vitallium and vitallium skull plates. They call attention to the fact that vitallium has been successfully used for bile duct tubes, ureter tubes and colostomy plugs. [ED. NOTE (D. H. O.).—This is an interesting review of the development and use of vitallium in many fields.]

Hughes<sup>384</sup> contends that since many communities have been deprived of their specialists the remaining physicians will have to be versatile. He lists the standard method of emergency treatment of fracture, which consists of temporary dressing and splinting, treatment of shock, administration of tetanus antitoxin, local application of sulfanilamide, local or general anesthesia for reduction, irrigation, débridement and plaster fixation. If x-ray equipment is not available, the percussion method of diagnosis of fracture may be used. With a stethoscope on the bone, the conduction waves indicate the condition of the bone. A list of improvised instruments is given for wiring or plating fractures. The author suggests that general practitioners should not attempt to use Smith-Petersen nails or Kirschner wire countertraction.

Magnuson<sup>385</sup> points out that complicated devices for traction cause the fundamental principles

382. Young, H. H.: Fracture Report for 1942. *Proc. Staff Meet., Mayo Clin.* 18:426-427 (Nov.) 1943.

383. Venable, C. S., and Stuck, W. G.: Clinical Use of Vitallium, *Ann. Surg.* 117:772-782 (May) 1943.

384. Hughes, T. J.: Some of the "Do's and Don'ts" with Special Reference to Rural Practitioner Who Present Emergency, *Virginia M. Monthly* 70:157-162 (April) 1943.

385. Magnuson, P. B.: Simplicity in Fracture Treatment, *Bull. Am. Coll. Surgeons* 28:135-137 (June) 1943.

379. Griffiths, H. E.: Rehabilitation of Joint Injuries, *M. Press* 209:166-168 (March 17) 1943.

380. Pugh, H. L.: Injuries of Bones and Joints, *Bull. Am. Coll. Surgeons* 28:130-132 (June) 1943.

381. Dickson, F. D.: Injuries of Bone and Joints, *Bull. Am. Coll. Surgeons* 28:137-138 (June) 1943.

traction, countertraction and manipulation to overlooked in the treatment of fractures. Each fracture must be treated in the manner best suited to it, and this can often be accomplished by simple bandages and traction loops. The author presents photographs showing traction being applied to fractures of the forearm, arm and leg with most elementary equipment.

Venable<sup>386</sup> presents a brief description and illustrations of an inexpensive, light, adjustable, wooden traction splint for either extremity. It may be adjusted to occupy little space for storage. [ED. NOTE (R. B. R.).—This seems an excellent substitute for any emergency splinting agency which cannot keep itself provided with Colles' Thomas splints.]

*Pathologic Conditions Associated with Fractures.*—Clark<sup>387</sup> reports the case of a soldier who received a blow on the right leg which resulted in a fracture of both bones in the middle third of the leg. Immediately there were severe pain and decreased circulation to the leg and foot, which finally caused gangrene and required amputation. [ED. NOTE (W. G. S.).—Reflex traumatic arterial spasm is rare. This is fortunate because it is attended by such severe symptoms that drastic treatment is required. Hermann, of Cincinnati, and Thomson, of Lincoln, Neb., have described the condition thoroughly and pointed out the probable causes. It is probably related to reflex post-traumatic

atrophy of bone ("Sudeck's"), which is often seen after relatively trivial sprains of the wrist and ankle.]

Meyer, Friedmann and Ginsberg<sup>388</sup> report a case in which a woman 52 years old, while under treatment for myelogenous leukemia, sustained a pathologic fracture of the right femur. When it is remembered that leukemia is a diffuse hyperplastic process involving all the marrow-containing bones, it is readily understandable that fracture should occur. Moreover, routine skeletal examinations of patients with chronic leukemia would undoubtedly reveal changes in the cortical structure of the long bones that predispose to fractures.

Cash and Hoekstra<sup>389</sup> believe that the introduction of electric shock has been a decided improvement in the management of mental disorders but its traumatic hazards have not been eliminated. Traumatic complications include involvement of the viscera in the form of petechial hemorrhages as well as fractures of the long bones and vertebrae. The authors feel that a safe and effective means of eliminating trauma incident to shock therapy is available in curare. In 139 patients receiving combined curare-electric shock treatments, there were no traumatic complications, and only 1 death occurred.

388. Meyer, L. M.; Friedmann, A. B., and Ginsberg, V.: Infiltration of Bone with Spontaneous Fracture in a Case of Chronic Myelogenous Leukemia, *Arch. Surg.* 46:514-517 (April) 1943.

389. Cash, P. T., and Hoekstra, C. S.: Preliminary. Curarization in Electric Convulsive Shock Therapy. *Psychiatric Quart.* 17:20-34 (Jan.) 1943.

## X. CONGENITAL DISLOCATION OF THE HIP

PREPARED BY A. BRUCE GILL, M.D., PHILADELPHIA

Badgley<sup>390</sup> reviews the theories of the cause of congenital dislocation of the hip and discusses the syndrome of arthrogryposis multiplex congenita. He concludes that the essential feature of his thesis is the evidence of a primary anterior displacement of the head associated with external rotation of the femur. Failure of normal rotation of the limb bud during embryologic life results in anteversion of the head and neck of the femur. Anteversion of the head produces the flat socket. The neck of the femur lies against the posterior rim of the socket, with the greater trochanter posteriorly. Hypoplasia of

the posterior rim results from this faulty pressure. The flat socket does not maintain the head in position. A gradual posterior displacement of the head and neck occurs as a result of the greater posterior angle of the os innominatum and the pull of the gluteal muscles.

Gill<sup>391</sup> analyzes and records his observations on the treatment of congenital dislocation of the hip over more than twenty-five years. Dislocation of the hip should be considered to be "cured" only when there has been perfect restoration of anatomic structure. After bloodless reduction there may be an absence of symptoms for many years (in 1 case twenty years) without

390. Badgley, C. E.: Correlation of Clinical and Anatomical Facts Leading to Conception of Etiology of Congenital Hip Dysplasias, *J. Bone & Joint Surg.* 5:503-523 (July) 1943.

391. Gill, A. B.: End Results of Bloodless Reduction of Congenital Dislocation of the Hip, *J. Bone & Joint Surg.* 25:1-40 (Jan.) 1943.

perfect anatomic restoration. Eventually pain, limp and tire on use appear. Anatomic restoration may take place within several years after reduction, or it may be delayed as long as ten or twelve years. Reduced hips that are symptom free should be kept under observation, and roentgenograms should be taken at regular intervals. The patients should not be discharged as cured until the acetabulum and the head of the femur have become normal. Dysplasia (defect in growth) of the acetabulum is the chief cause of subluxation or complete luxation of the hip subsequent to reduction. The earliest indication in the roentgen films of upward displacement of the head of the femur, whether it appears early or late (even as late as ten or fifteen years after reduction), demands a surgical operation to reconstruct the acetabulum. Outward displacement of the head of the femur, provided there is no upward displacement, is not an indication for surgical intervention, as the hip may eventually become normal. Dysplasia of the head of the femur (delay in its development and its calcification) is of less importance than dysplasia of the acetabulum. But defective calcification (which is not Legg-Perthes disease) is probably an indication that weight bearing should be prevented or restricted until the epiphysis of the head has attained a uniform density. The author no longer does a "shelf operation" on children under 5 years of age if upward displacement occurs when the leg is brought to the longitudinal axis of the body but holds the head down and pointing into the socket by means of an abduction brace. If upward displacement, with the extremity in this position, persists until the child is 5 years of age, the author does not hesitate longer to perform the "shelf operation." The end results of bloodless reduction (or of open reduction also) can be determined only after many years of observation of all dislocations that have been so reduced. Of 126 dislocated hips treated by the author only 14.3 per cent have been proved to be "cured." However, not all of the 126 remained under observation long enough to determine that perfect anatomic restoration occurred. Sixty-five and three-tenths per cent of 98 dislocated hips which were under observation from two to twenty years were proved to be unsuccessfully reduced. The successful reductions may be assumed to be 34.7 per cent. Therefore, the number of successful reductions ("cured") must be somewhere between 14.3 and 34.7 per cent. The statistics of authors who formerly estimated their successful reductions to be 60 per cent or more were false, be-

cause their cases were not kept under observation a sufficient number of years to determine true end results. The records demonstrate that many hips may remain satisfactorily reduced (symptom free) for many years but eventually are proved to be subluxated. Approximately two thirds of the redislocations occur during the first two years following a bloodless reduction and the remaining third during the subsequent years (in 1 case twenty years after reduction). Bilateral dislocations, if they can be reduced, give as high a percentage of cures as unilateral dislocations. Of 24 hips (12 cases), 7 became perfect (cured). The author emphasizes the importance of long-continued observation of a cases of congenital dislocation that have been reduced by the bloodless or by the open method. Subluxation should be recognized, as it is indicated by the appearance of symptoms, and it should be treated by an operative procedure to make an acetabulum as nearly like a normal acetabulum as is possible. Until perfect anatomic structure and relation have been attained, the congenital dislocation cannot be considered as "cured," no matter how perfect the function. The paper is illustrated with many roentgenograms which demonstrate the statements made by the author.

In cases of irreducible congenital dislocation of the hip subtrochanteric osteotomy, devised by Lorenz and by Schanz, is a recognized procedure, although it is not uniformly successful in relieving the symptoms. Hass<sup>392</sup> has found valuable a method of osteotomy for pelvic support with which, by using a locking subtrochanteric osteotomy and displacing the lesser trochanter into the acetabulum, he has secured good stability and freedom from pain as well as an adequate range of motion. The procedure is indicated for supracotyloid dislocations but can also be employed for dislocations of the ilium at a high level after preliminary skeletal traction. Eighteen patients, of whom 4 had bilateral dislocations, have been treated by this method. The author finds the end results to be better than those obtained by other methods of treatment.

Elsner<sup>393</sup> describes 3 cases of genuine congenital dislocation of the hip, in 2 of which deformity could definitely be classified as teratologic, whereas in the third case it was neither a teratologic dislocation nor a so-called co-

392. Hass, J.: A Subtrochanteric Osteotomy for Pelvic Support, *J. Bone & Joint Surg.* 25:221-224 (April) 1943.

393. Elsner, W.: Question of Genuine Teratologic Congenital Dislocation or Intra-Uterine Trauma, *Ztschr. f. Orthop.* 73:193-200, 1912.

genital dislocation. He suggests in this case an intrauterine traumatic origin. The case is compared in detail with cases of teratologic dislocation of the hip, which is discussed thoroughly.

Hein<sup>394</sup> presents a series of 87 cases in which serial roentgen study was made of infants born in definite breech presentation. In 4 of these cases, or 4.59 per cent, the infants had congenital dislocation of the hips. Attention is drawn to the high incidence of congenital anomalies and twin births in the families and among the children themselves. It would seem that antenatal forced position due to deviation of the position of the fetus may play some part in congenital dislocation of the hip, but no general conclusions are permissible. The studies are to be continued.

Ottolenghi<sup>395</sup> reports briefly 7 cases of tibial transplantation for reconstruction of the roof of the cotyloid cavity. He concludes that the iliac osteoplastic shelf method of repair of the roof of the cotyloid cavity in children fails in a high percentage of cases and that much better results are obtained with a tibial graft. Twenty-one figures show roentgenograms indicating the results of operation in the cases cited.

Platt<sup>396</sup> reviews the history of congenital dislocation. Manipulative reduction is discussed, and the need for gentleness is stressed. He analyzes his personal experience with 50 patients who have been followed for over ten years. Of 62 hips, 46 are reported as functionally satisfactory and 29 as anatomically good. The causes of failure are divided into (1) extrinsic causes—bad selection of cases, choice of wrong method or inefficient after-treatment; (2) intrinsic causes—anomalies of the joint capsule and skeletal anomalies, including osteochondritis. He points out that residual subluxation calls for further

treatment by either the closed or the open method. Open reduction is indicated for: (1) young children when there is evidence that the intrinsic obstacles to reduction are formidable; (2) older children when closed reduction is obviously impracticable; (3) residual subluxations following closed reductions. The use of the divaricator in the first year of life is described.

Sutherland and Rowe<sup>397</sup> make use of a metal prosthesis to replace a deficient superior acetabular margin in a subluxating hip. A short lateral longitudinal incision is made. The gluteal muscles are split above the greater trochanter in the line of their fibers, and a small area of the ilium above the acetabulum is exposed. A small metal shelf is applied and held in place with screws. No cast is used, and motion of the hip is begun early. The advantages of this procedure over shelf operation are cited: (1) No arthrotomy is performed, and thus no ankylosis occurs; (2) no stripping of the gluteus medius and minimus muscles is done, and so no weakness of abductor muscles occurs; (3) it is less shocking, because less blood is lost, osteotomy is not performed and the operating time is less. Three cases are reported.

Whiston<sup>398</sup> reports a series of 48 cases of congenital dislocation of the hip observed from seven to eighteen years after reduction. The cases are classified and tabulated according to technic followed, roentgen studies, complications and type of dislocation present. It is noted that (1) patients under the age of 5 years treated by closed reduction presented results superior to those in older age groups; (2) a postreductive immobilizing period extending over ten months produced more cures in this age group than when a shorter period of fixation was used. Complications encountered are recorded.

397. Sutherland, R., and Rowe, M. J., Jr.: Metal Shelf for Hip Dislocation, *Am. J. Surg.* **62**:206-210 (Nov.) 1943.

398. Whiston, G.: Congenital Dislocation of Hip with Special Attention to After-Care Period and Late Postreductive Results, *Surg., Gynec. & Obst.* **77**:307-314 (Sept.) 1943.

## XI. CONDITIONS INVOLVING THE SPINE AND THE THORAX

PREPARED BY JOHN R. COBB, M.D., NEW YORK

*Anatomic Variations.*—In an interesting and beautifully illustrated paper, Ehrenhaft<sup>399</sup> describes the development of the vertebrae and the intervertebral disks and correlates develop-

mental peculiarities with certain lesions found in later life. He believes that an understanding of the blood supply and its fate is of special importance for the understanding of the later development of the intervertebral disk and states:

399. Ehrenhaft, J. L.: Development of the Vertebral Column as Related to Certain Congenital and Pathological Changes, *Surg., Gynec. & Obst.* **76**:282-292 (March) 1943.

The explanation of some of the nucleus pulposus into the spongiosa of the vertebral bodies occurring at an age when the senescent degenerative changes of the

cartilaginous plates are only minimal can be based on it. The intervertebral disc is constantly exposed to more or less severe trauma and it is one of the earliest structures to show definite senescent changes. This is partly explainable on the development and the early regression of the vascular supply.

After a careful description of the blood supply, the author states:

Regression and scarring starts shortly after birth and slowly progresses to completeness by the age of 18 to 25 years, at which time most of the growth has stopped and the bony ring epiphysis has fused with the vertebral bodies proper. Where those vessels have penetrated the cartilaginous plates some chondrification gaps result. These are replaced at the time of complete degeneration of the vessels by either cartilaginous plugs or by scar tissue and sometimes by calcification. They are areas of lessened resistance to the increased turgor of the semisolid intervertebral disc substance especially the disc is subjected to increased pressure.

Ehrenhaft's finding of no elastic tissue fibers within the annulus during embryonic life or in an 18 month old child differs from the observations of some other investigators.

The author points out that developmental defects of the spinal column have been poorly understood and that one has to differentiate between the malformations occurring in the vertebrae—column of intervertebral disks—and those along the neural column, formed by the neural arches. He believes that the latter malformations have a close relationship with developmental defects of the neural tube. He also feels that not all developmental defects in the vertebral—disk column—can be explained on the basis of malformations in the mesenchymal and cartilaginous embryonic states, though many become easily understandable if one considers the vascular supply and the changes which occur in the notochord during the different stages. He discusses the cause and formation of congenital deformities of the spine.

There are considerable confusion and misunderstanding regarding the problem of juvenile kyphosis, and Ehrenhaft's discussion on this seems worth quoting:

Multiple spongiosal nuclear prolapses with juvenile kyphosis in the young adolescent groups occur mostly in boys subjected to very heavy manual labor. One must keep in mind that at this age there is still good blood supply to the intervertebral disc tissue and not all the vessels have degenerated. The nucleus pulposus is still rather liquid and easily displaced. Scheuermann, basing his observations and this theory only on x-ray findings, states that the deformity is due to an aseptic necrosis—an "epiphysitis" of the ring epiphysis which is undergoing marked ossification at about this age. Schmorl and since then others have examined, at autopsies, numerous spines of adolescent patients with juvenile kyphosis, and they found large nuclear prolapses into the spongiosa through the cartilage plates. These prolapses are in a location which is usually the one where some of the chondrification gaps have occurred due to de-

generated vessels producing weak points. It also has been proved fairly conclusively that the ring epiphysis has nothing to do with the growth in the height of the vertebral bodies. This growth in the height is exclusively a function of the cartilage plate which is central to the ring epiphysis and underlies the rim ledge proper. Nuclear prolapses of juvenile kyphosis often occur all along the vertebral bodies of the lower thoracic and upper lumbar region. The uneven growth in height of individual vertebrae tends to retard the growth anteriorly where the increased pressure load is concentrated. More normal growth occurs posteriorly. Thus, the relative wedging of the vertebral bodies is secondary to the improper mechanical function of the degenerating narrowed intervertebral disc. In this way the kyphotic deformity results. The fragmentation of the anterior portion of the ring epiphysis seen in x-ray pictures results from improper motion, abnormal pressure relationship, and shearing stress put upon the anterior annulus fibers and the unfused ring epiphysis.

[Ed. NOTE.—This is an excellent article and should be read by every one interested in spinal lesions. The author's explanation of the cause of juvenile kyphosis is especially interesting in contrast with the theories of those who believe that it is caused by epiphysitis or some glandular or vitamin deficiency. While he does not discuss treatment, his theory certainly adds considerable emphasis to the importance of rest in labor or avoidance of fatigue, heavy with juvenile kyphosis. In the light of this theory, the use of spinal braces to reduce stress and strain on the involved vertebrae and the consideration of earlier spinal fusion in the area of the wedged vertebrae may be indicated more frequently for adolescent kyphosis than has been practiced by most orthopedic surgeons.]

Romanes<sup>400</sup> reports a study of the spinal cord of a newborn child whose right lower limb was missing from the knee joint distally. He found a distinct reduction of the right side of the spinal cord in the lumbosacral region. This affected the posterior column, the root of the sacral plexus and the posterior and anterior horns of gray matter, the anterior horn showing almost total loss of the posterolateral and the posterolateral column of motor cells, which supply the nerves to the leg and foot. The loss of these columns of cells of the anterior horn is considered to be the result, not the cause, of the developmental insufficiency of the peripheral mesoderm. The author points out that while these findings are valuable in determining central peripheral relations of the spinal cord and the muscles of the limbs, they throw no light on the mechanism of development.

400. Romanes, G. J.: The Spinal Cord in a Case of Congenital Absence of Right Limb Below the Knee. *J. Anat.* 77:1-5 (Oct.) 1942.

Moreton<sup>401</sup> discusses the problem of basilar invagination and reports a study of a series of 139 cases, in 41 of which associated congenital changes were present in the cervical portion of the spinal column and in 98 of which such changes did not exist. In conclusion he states:

1. Persons who have basilar invagination, as diagnosed by means of Chamberlain's line, may go through life without symptoms. 2. Diagnosis depends on closer association of clinician and roentgenologist. Such association will aid detection of the condition in cases in which other diagnoses have been given. 3. Associated congenital anomalies, especially of the upper cervical vertebrae, are important in increasing the chances of this condition manifesting itself clinically. If these congenital changes exist, the manifestations usually occur at an earlier age than that at which they occur if the changes do not exist. 4. Basilar invagination may cause symptoms without there being a definite increase in the basilar angle. 5. Patients with basilar invagination secondary to Paget's disease may show symptoms of the primary disease only. 6. Treatment is decompression.

Eaton<sup>401</sup> discusses Moreton's paper and stresses the importance of differential diagnosis. He feels that the paper by Chamberlain on platybasia must be given credit for stimulating interest in congenital malformations in the region of the foramen magnum. Since its publication clinicians have been reluctant to classify certain conditions as multiple sclerosis, syringomyelia, familial cerebellar ataxia and tumor of the brain or of the upper cervical portion of the spinal cord without careful roentgenographic study to exclude bony malformations in the region of the foramen magnum, which may produce a somewhat similar clinical picture.

Eaton also states:

The symptoms produced are not difficult to remember if the structures affected are kept in mind. The medulla and spinal cord join at the level of the foramen magnum. If the foramen is narrowed by a congenital malformation which allows the odontoid process to dislocate posteriorly, signs of compression of the upper cervical portion of the cord result and spastic weakness of the legs and arms with Babinski and other signs of pyramidal involvement may be produced. Nystagmus, absent abdominal reflexes, paresthesias, ataxia and inco-ordination may be present also. Furthermore, remissions and exacerbations occur. One can readily understand why with such a clinical picture the condition may be confused with multiple sclerosis.

**Diagnostic Signs.**—The linear thoracic paraspinal shadow which is often seen in anteroposterior roentgenograms of the chest has been hard to explain. In the solution of this problem, Brailsford<sup>402</sup> and Garland<sup>403</sup> independently refer to

401. Moreton, R. D.: Basilar Invagination: So-Called Platybasia, Proc. Staff Meet., Mayo Clin. 18: 353-357 (Sept. 22) 1943.

402. Brailsford, J. F.: The Radiographic Postero-Medial Border of the Lung or the Linear Thoracic Paraspinal Shadow, Brit. M. J. 1:219-220 (Feb. 20) 1943.

403. Garland, L. H.: The Postero-Medial Pleural Line, Radiology 41:29-33 (July) 1943.

an editorial in *Radiology*, August 1942, page 229, which draws attention to the following:

A slender vertical line of demarcation is often seen in anteroposterior or sagittal roentgenograms of the bony thorax and upper abdomen. This line lies on the left side of the lower two-thirds of the thoracic spine and sometimes continues as far down as the plane of the first two lumbar segments. . . . It is not visible on all films or projections of this portion of the body but is observed with such frequency that it must be the result of variation in the course or position of a normal structure situated therein.

Both Brailsford and Garland believe that this line is the border of the lung. After a discussion of the anatomic considerations, Brailsford emphasizes the line as an important diagnostic sign.

It shows the close relation of the medial border of the lung to the lateral surface of the vertebral body. If the latter is crushed its transverse diameter will be increased and the medial border of the lung will be displaced to that extent laterally. If the fracture is associated with a paravertebral haematoma this will show as an added expansion and further lateral displacement of the medial border of the lung. The antero-posterior radiographs show this as a fusiform expansion of the medial opacity, for the postero-medial border of the right lung will be similarly displaced. In a case which came to court the existence of a crush fracture of the vertebral body was disputed until the presence of a paravertebral haematoma was demonstrated to the judge on the radiograph taken a fortnight later. But the commonest demonstration of lateral displacement of the postero-medial border of the lung is due to the paravertebral tuberculous abscess. It is important because it may be detected before any change in the bone has become apparent. The abscess may extend the whole length of the dorsal spine, is usually fusiform in shape, and is sometimes of the width of the heart shadow; indeed, it has occasionally been missed because it was mistaken for the latter. It may show progressive expansion from the time it is first detected. Because from the level of the reflection of the pleura on to the diaphragm there is below no contrast in the densities of the adjacent tissues, the outline of the abscess cannot be traced in the abdomen—i. e., we are dependent upon the lateral displacement of the posterior-medial border of the radiotransparent lung for visualization of the abscess. Consequently, though the abscess may have arisen from caries of one of the lumbar vertebrae, if no bone changes are yet recognizable its origin may not be apparent.

Because of this common appearance of the dorsal tuberculous paravertebral abscess there is a tendency to diagnose all fusiform deviations of the postero-medial border of the lung as tuberculous in origin, but appreciation of the anatomical features I have described which give rise to these shadows induces further discrimination. Thus neoplasm, both primary and secondary, may cause collapse and an increase in the transverse diameter of the diseased vertebral body; this will cause a lateral deviation of the postero-medial border of the lung, which will be increased, if there is proliferation of neoplastic cells or if associated with haemorrhage, to such an extent that it may resemble a paravertebral abscess. It should be remembered, however, as a feature in differential diagnosis, that neoplasm appears to spare the disks even though all the vertebral body is destroyed.

Fusiform paravertebral expansions have been seen at the site of pneumococcal, typhoid, and paratyphoid

abscesses. In these the destructive changes are more frequently present in the disk, which appears to collapse, and within a few weeks the postero-medial border of the lung is straightened out again. The vertebral bodies ultimately fuse. In the acute phase of *vertebra plana* the involved body is surrounded by fusiform expansion, which within a few weeks gradually disappears, leaving the disk apparently intact but the elements of the vertebral body compressed to a quarter or a third of the normal depth. In Paget's disease that is localized to one or more dorsal vertebral bodies the postero-medial border of the lung is deviated laterally by the expansion of the bodies. In osteochondritis of the spine in infants and adolescents some degree of thickening of the tissues adjacent to the vertebral bodies occurs, and the medial border of both lungs may become apparent just lateral to the border of those bodies; but in this there is no localized fusiform expansion.

In one case rupture of the posterior wall of the vertebra was associated with haemorrhage into the areolar tissue surrounding the vertebral bodies: an appearance simulating a paravertebral abscess was produced. Any inflammatory or neoplastic proliferation within the vertebral body or the areolar tissue surrounding it may produce changes such as have been described, and it may be necessary to seek elsewhere for a clue to the identity of the organisms and cells producing the displacement of the lung. Empyema localized to this site would also push the lung laterally.

[ED. NOTE.—Undoubtedly many orthopedic surgeons have been confused by this "postero-mesial pleural line," and it seems worth while to draw attention to its diagnostic significance.]

*Roentgenographic Technic.*—Gunson<sup>404</sup> discusses the anatomy of the sternoclavicular articulation and the roentgenographic technic to visualize this area adequately. He describes six projections for visualization of the sternoclavicular joint.

Judd<sup>405</sup> points out that there are occasions when satisfactory views of the odontoid process of the axis are difficult to demonstrate with the routine anteroposterior views taken through the open mouth. For a modified occipitomeatal projection he places the patient in the prone position, the head adjusted so that the chin is resting on the table and the nose is  $1\frac{1}{4}$  inches (3 cm.) from the table top. The x-ray tube with a small cone should be centered so that the central ray, at right angles to the film, will pass through the vertex of the skull and the foramen magnum. The resultant roentgenogram will show the odontoid process framed in the foramen magnum. This projection is not intended to supersede the routine anteroposterior view but is recommended when satisfactory films are unobtainable by the usual methods.

404. Gunson, E. F.: *Radiography of Sternoclavicular Articulation*, Radiog. & Clin. Photog. (no. 1) 19:20-24, 1943.

405. Judd, G.: *A Useful View of the Odontoid Process of the Axis Vertebra*, Radiography 9:46-47 (June) 1943.

*Surgical Operations on the Spine.*—Local infiltration anesthesia induced with a procaine hydrochloride solution containing epinephrine hydrochloride is the anesthesia preferred by Freiberg and Perlman<sup>406</sup> for most spinal operations, including fusions, laminectomies and combined procedures. They suggest that induction of anesthesia be preceded by administration of barbiturate, to act as a mild sedative but primarily to prevent reactions to procaine. In their last 17 cases as excellent an anesthetic effect was obtained with only 0.5 per cent solution of procaine hydrochloride with epinephrine as with equal amounts of a 1 per cent solution. They report only 1 instance of apparent allergic or hypersensitive reaction to procaine in several hundred cases in which infiltration anesthesia was employed and a satisfactorily low incidence of complications in a series of 54 spinal operations from 1939 to 1942. The authors feel that the disadvantages of and the contraindications for the use of local infiltration anesthesia are few, but the psychoneurotic patient, the patient speaking only a foreign language or the patient who expresses a definite objection to this type of anesthetic should be given a general anesthetic. The preoperative medication consisted of administration of a barbiturate, preferably pentobarbital sodium,  $\frac{3}{4}$  to  $1\frac{1}{2}$  grains (0.05 to 0.09 Gm.) at bedtime and again one to two hours before operation and morphine with atropine or scopolamine about a half-hour before operation.

Procaine was also used for removing the tibial graft. After the skin and subcutaneous tissues were infiltrated and before the periosteum was exposed or the skin incised the fine gage needle was inserted to the underlying bone and at  $1\frac{1}{2}$  inch (3.8 cm.) intervals about 1.5 cc. of procaine hydrochloride solution was injected. No further infiltration was required for osteoperiosteal grafts, but when full thickness grafts were cut some pain was felt when the endosteum was encountered. In recent cases the authors injected 1 or 2 cc. of procaine hydrochloride solution into the tibial medullary canal through small drill holes at the extremities of the site of the proposed graft, the hub of the short needle occluding the osseous holes during injection. This intramedullary injection of procaine induced complete anesthesia or made the pain negligible.

[ED. NOTE.—There are certain definite advantages of local infiltration anesthesia for spinal operations. However, while gentleness is desirable one usually does have to proceed more slowly

406. Freiberg, J. A., and Perlman, R.: *Local Infiltration Anesthesia in Spine Surgery*, J. Bone & Joint Surg. 25:145-152 (Jan.) 1943.



with local than with general anesthesia, and when a long area is to be fused it may be necessary to do the operation in several stages with local anesthesia, while the whole area might be fused in one stage with general anesthesia. If general anesthesia reduces the number of operative procedures, it would seem preferable to local anesthesia, though there is no doubt that local anesthesia is best in certain cases, and it should be used more generally.]

Howorth<sup>407</sup> discusses the various stages and procedures in the development of spinal arthrodesis. In discussing the early period of development of the fusion operation, he states:

Despite the several technics described, this early period was marked not so much by study of the technic of spinal fusion, as by discussion as to whether spinal fusion was justified at all. . . . It was found, over a period of years, that growth of the spine continued at the normal rate after fusion, and that the trunk-leg ratio remained the same in these patients as in normal individuals, allowing for the effect of the kyphos.

[ED. NOTE.—It should be pointed out that the vertebral body which is involved by tuberculosis is frequently deformed and does not grow normally, since its growth centers are involved. One therefore would not expect fusion of the posterior element to disturb appreciably the alignment in the fused area. It should be stressed, however, that in some cases of scoliosis the vertebral bodies do continue to grow while the fused posterior portion of the spine is retarded or stationary. This is especially true for patients with scoliosis following poliomyelitis. A number of cases have been studied and reported in which there was a definite posterior concavity in the fusion area following spinal fusion for scoliosis in children who continued to grow, although this work has not yet been published.]

Howorth discusses the application of spinal fusion to other conditions besides tuberculosis and scoliosis and summarizes the indications for operation as follows:

1. Tuberculosis: The treatment of choice at all ages, unless complete spontaneous natural fusion can be demonstrated, or the general condition of the patient or complications preclude the operation.

2. Scoliosis: In children with rapidly progressive deformity, or deformity with decompensation which can be corrected sufficiently to warrant fixation; in adults occasionally for relief of pain.

3. Spondylolisthesis: All cases in the lower lumbar region unless contraindicated by age or the general condition of the patient.

4. Other lumbosacral anomalies: Pain of long duration, of moderate or great intensity, frankly due to the anomaly and unrelieved by other treatment.

5. Rupture of nucleus pulposus: Many of these joints are unstable primarily, and should be fused upon removal of the nucleus, preferably without laminectomy.

6. Compression fracture of the spine and some dislocations: As a means of maintaining reduction, hastening convalescence, and preventing pain.

7. With laminectomy: When indicated with a coincident orthopedic condition, or an extensive procedure.

8. Special indications in certain other conditions.

The author also gives a complete description of the operative technic, with illustrations of the various steps in the technic, and feels that denuding the articular cartilages is the most crucial point in the fusion. He also feels that "the chief feature of postoperative care is proper immobilization of the spine by bed rest and a brace or plaster jacket until the fusion has become sufficiently strong to support the weight of the trunk, and ordinary body movements." He states that "those with scoliosis are operated upon through a fenestrated plaster jacket, and the jacket is then reinforced. Other cases have a Taylor brace applied."

[ED. NOTE.—It is interesting to note that many surgeons have obtained satisfactory solid spinal fusion without including the articular facets, and, as Howorth states, "It matters not so much how a particular chip is laid or from whence a particular fragment of bone comes, but as to whether fusion is obtained, how quickly and how strong."

There are obviously many variations of the technic for spinal fusion which are satisfactory, and the particular detail depends on the preference and ability of the individual surgeon.

Howorth concludes:

The effects of the operation should be clearly understood. A fusion may hasten and assure healing of tuberculosis and perhaps sometimes other infections, by completely immobilizing the diseased section of the spine. Progressive deformity due to tuberculosis, scoliosis, and spondylolisthesis may be prevented. The establishment of fusion for this purpose in cases of round back or hemivertebrae is open to question. In scoliosis and fracture, fusion may be the best or only means of maintaining correction of deformity. We do not attempt, and advise against attempting, to correct the deformity in tuberculosis. Fusion may be used for the relief of pain in the lumbosacral anomalies as well as all of the conditions just named. In many cases it may not only aid in the cure of the disease, the arrest or correction of deformity, and the relief of pain, but may be the quickest and most economical method of relief, in this way offering a financial advantage to both patient, hospital, and community. Thus, we see that spinal fusion has evolved during the past 30 years from a "radical" procedure in the treatment of tuberculosis, to a well established operation employed for a number of abnormalities of the spine. It is not a panacea, but in properly selected cases, and in skilled hands, fusion offers little risk and the possibility of great benefit to a large number of patients.

[ED. NOTE.—This is an excellent article and covers the history and development of spinal fusion operations, with twenty-four references on the subject.]

407. Howorth, M. B.: Evolution of Spinal Fusion. *Ann. Surg.* 117:278-289 (Feb.) 1943.



Meyerding<sup>408</sup> discusses the results of surgical treatment for spondylolisthesis. He reports a study of 876 cases of spondylolisthesis observed between 1922 and 1940 inclusive, with operations in 143, or 16.3 per cent. The paper is based chiefly on the 143 cases in which operations were performed. He also discusses the coexistence of spondylolisthesis and protrusion of an intervertebral disk and found these two lesions associated in 7 of the 143 cases. The average duration of symptoms before operation was six and three-tenths years, and in most of the cases conservative treatment had failed to give relief.

[ED. NOTE.—Many orthopedic surgeons feel that it is not worth while to try conservative treatment for spondylolisthesis when the symptoms are severe and start at an early age, while patients beyond the age of 50 before the onset of symptoms are frequently relieved by an adequate back brace.]

In discussing treatment the author describes the fusion operation which he prefers. In the fusion procedure he includes curetting the articular facets and inserting two grafts from the tibia and sometimes numerous shavings from the tibia. At the end of six weeks the patient is permitted up with a lumbosacral canvas corset in which a steel rectangular leather-covered pad has been sewed. Plaster casts are rarely used. The support is worn from four to six months after operation.

In discussing the results in 118 cases in which follow-up data were available, the author reports that the results were good in 60.1 per cent, they showed improvement in 28 per cent and they showed no improvement in 11.9 per cent. He reports postoperative complications in 14 cases, infection in 8 and phlebitis in 6. There was no operative mortality in any of the 143 cases. The author states that in 87.6 per cent of the 118 cases the patients were able to engage in gainful occupations after operation, and in 66.4 per cent they were able to resume their former occupations.

[ED. NOTE.—This is an excellent report on the treatment of spondylolisthesis, with illustrations of the operative technic and numerous tables of statistics. It might be mentioned, however, that many orthopedic surgeons consider it unnecessary to include the third lumbar vertebra in fusions for spondylolisthesis of the fifth lumbar area. If the fusion is solid from the fourth lumbar vertebra to the sacrum there should be no need to include the third lumbar vertebra,

although apparently many surgeons still do is also noted that the author does not statistics on the number of pseudarthroses following this method of fusion.]

Toumey<sup>409</sup> describes a method of internal fixation for fusion of the lumbosacral joint

After a description of the usual method exposure of the lumbosacral area and removal of the disk if necessary, the author describes the fusion procedure, which consists of removal of the articular cartilage from the lumbosacral facets, insertion of small bone chips into the interval between the facets and insertion of a vitallium screw,  $1\frac{1}{8}$  inches (3 cm.) long, with coarse threads and Phillips recessed head, through and across the facets, to fix the lumbosacral facets. Additional bone chips from the sacrum are then placed in the small sacral hole immediately below the facet and extending over the articulation. The same procedure is then carried out on the other side. The screws are placed to immobilize the lumbosacral joint immediately and to maintain internal fixation until bony fusion of the facets takes place. They are also placed to transfix the facets and enter the large, thick, lateral portion of the first sacral segment.

The patients were kept in bed for three weeks after operation, and while in bed they wore a brace or support. When they became ambulatory, the men wore a canvas lumbosacral brace and the women a corset.

[ED. NOTE.—This is an interesting procedure and has definite advantages in fusions of the lumbosacral area. However, in a high percentage of these fusions (especially those done for spondylolisthesis and for a lesion of a disc involving the joint between the fourth and fifth lumbar vertebrae) it is necessary to extend the fusion to the fourth lumbar vertebra or higher and in these cases there would still be the problem of immobilizing the joints to be fused above the fifth lumbar vertebra. The Wilson spine plate has proved satisfactory for obtaining immediate immobilization of a number of joints at once and can be used for fusion of any number of lumbar vertebrae if necessary. A difficulty, however, has been that sometimes the spinous processes on the sacrum have been too small to hold a bolt adequately, so the plate could not be used. This difficulty has been partially solved by the use of J or C bolts around a spinous process too small for drilling for a straight bolt. In some cases in which there is no sacral spinous

408. Meyerding, H. W.: Spondylolisthesis: Surgical Treatment and Results, *J. Bone & Joint Surg.* 25:63-77 (Jan.) 1943.

409. Toumey, J. W.: Internal Fixation in Fusion of the Lumbosacral Joint, *Lahey Clin. Bull.* 3:182-191 (Oct.) 1943.

process and the fusion has to extend above the fifth lumbar vertebra, it will probably be worth while to combine these two methods and use the Toumey method for immobilization of the lumbosacral area and a Wilson plate to immobilize the joints above.]

Vom Saal<sup>410</sup> describes a method for fusion of the thoracic portion of the spine in which the transverse processes are completely removed subperiosteally and used as additional grafts.

The author feels that "mechanically from this procedure there is a great increase in strength, not only because it nearly doubles the usual fusion width, but also because it provides forward extensions, bringing the fusion mass closer to the axis of the spine." He states that the fusion area produced now resembles a "channel" rather than a rectangular section beam, using a complicated engineering formula to prove this.

The author also states

The question has been raised whether removal of the rib articulations might not result in rib fusion, with splinting of the chest and respiratory embarrassment. Eight of the fifteen patients whose spines were fused by this method have had careful measurements of the chest and vital capacities, beginning six months before operation and extending to one to three years after operation. In none has the postoperative vital capacity or chest expansion decreased.

Two roentgenograms are included showing extension of the fusion to most of the ribs. Two cases are reported, in 1 of which the vital capacity was 30 per cent of normal and there was almost complete paralysis of all respiratory muscles except the diaphragm; with the constant postoperative use of empyema blow bottles "the vital capacity continued to increase, and is now 60 per cent of normal." In the other case there was obvious inclusion of some of the ribs in the fusion. "In spite of this, the vital capacity increased 20 per cent postoperatively, and the chest expansion has remained the same."

[ED. NOTE.—Most orthopedic surgeons are usually able to obtain satisfactory solid spinal fusions in the dorsal area by the Hibbs or the Mackenzie-Forbes method, with or without additional bone, and removal of extra bone from the tibia or iliac crest is not often difficult. It is doubtful whether it is necessary to remove the transverse processes for thoracic spinal fusion, and the desirability of obtaining fusion of the ribs is questionable. In a case of severe scoliosis following poliomyelitis with no motion of the chest and only diaphragmatic and abdominal breathing, obviously fusion of the ribs would not decrease the expansion of the chest

and so would not decrease the vital capacity. However, it is usually conceded that motion of the ribs is necessary for expansion of the chest, and in cases of ankylosis of the joints of the ribs with Marie-Strümpell arthritis the patients usually have diminished expansion of the chest. It is difficult to see how there was no decrease in the vital capacity or expansion of the chest postoperatively in any of these cases if the joints of the ribs were fused, as claimed by the author, unless there was no motion of the joints of the ribs before operation. It might be mentioned that the roentgenograms in this article which show "extension of the fusion to most of the ribs" are oblique views, and in an oblique view the shadow of the fusion area is usually thrown to one side, often apparently overlying the ribs. This is especially true after fusion for scoliosis when there is still some residual curve. As a matter of fact, oblique views are usually taken postoperatively for this reason, in order to show the continuity of the fusion area on one side.]

Swart<sup>411</sup> concludes that "the posterior bone graft when properly placed is sufficient to stand any ordinary strain placed on the back." He points out that some authors have stated that the results of the use of posterior grafts for spondylolisthesis were unsatisfactory, which led to the search for a new method. The author presents a case in which compression of the fourth lumbar vertebrae resulted from a fall over a year after spinal fusion for spondylolisthesis, to show that a single posterior bone graft possesses all the strength necessary for solid fixation. In spite of an injury sufficient to cause a compression fracture of the fourth lumbar vertebra the fusion area remained intact.

[ED. NOTE.—The fusions for spondylolisthesis obtained by many various methods, including the single posterior graft, are usually satisfactory to stand all normal strains if the procedure is done properly with an adequate amount of bone and a really solid fusion is obtained. Failures of fusion are almost always due to poor technic, inadequate bone in the fusion area or insufficient postoperative immobilization. It might be mentioned, however, that there is an increasing trend toward the use of the various methods employing numerous interdigitating bone chips in slivers rather than one single large bone graft, which depends for its success on its fusion to several spinous processes and frequently does not fuse to one or more of them.]

410. Vom Saal, F.: Thoracic Spine Fusion: A Method. *J. Bone & Joint* 25:49-52 (Jan.) 1943.

411. Swart, H. A.: Spondylolisthesis Treated by Posterior Bone Graft: Fracture of Vertebra Above Graft. *South. Surgeon* 11:846-848 (Dec.) 1942.

Collins<sup>412</sup> reports a case of unusual fracture of the second cervical vertebra in which the body of the second cervical vertebra was dislocated forward and down in front of the third cervical body yet there was only generalized muscular weakness of the left arm. The patient was treated with continuous traction for one month, and later a neck brace was worn for one year, after which time there were only a moderate decrease in rotation and extension of the head and no abnormal neurologic findings.

*Ankylosing Spondylarthritis.* — Baker,<sup>413</sup> in discussing ankylosing spondylarthritis, points out that the condition is more common than is indicated in the literature, partly because of the various names under which it has been discussed but probably more because of the frequency of mistaken diagnosis. The author believes that recent reports of excellent results obtained by roentgen therapy have created a new interest in this disease, have made early and correct diagnosis important and have warranted a review of the subject and improvement in orthopedic care if full benefit is to be obtained by combined orthopedic and roentgen ray treatment.

He discusses the early symptoms and the later development of symptoms, the roentgen findings and the course of the disease. He reports most satisfactory results with a combination of orthopedic and roentgen therapy. He describes the method of treatment, which includes rest in bed, hyperextension of the spine, traction if necessary and physical therapy, including heat massage and corrective exercises, with special attention given to securing relaxation of the abdominal muscles. He describes the methods of exercise and an apparatus designed to prevent hyperextension of the lumbosacral area and to aid in the correction of the dorsal curve and the development of the thoracic bundles of the sacrospinal muscles. He also describes an excellent brace for use in these cases. This brace seems to have some definite advantages over other braces which have been used. The author, however, does not say how long the brace should be worn and whether it is used only during the early stage of the disease or during the manifestation of symptoms. He states that the patient's general health has been improved and the sedimentation rate lowered. He, however, admits that too short a time has elapsed to determine whether roentgen therapy is only analgesic or whether it has a deterrent effect on the disease

and will serve to prevent further ossification of the ligamentous structures of the spine.

[ED. NOTE.—This is an excellent article combined roentgen and orthopedic therapy spondylarthritis. The author's three point perextension brace is well illustrated and many practical advantages over most braces for this purpose.]

Hilton<sup>414</sup> reports 62 cases of ankylosing spondylitis in which roentgen therapy was used. He prefers local application over a small field rather than over a wide field, or the bath technic, which he feels has various grave disadvantages. He believes that it is worth while treating all patients with ankylosing spondylitis, whatever the stage, except when there is complete ankylosis coupled with entire absence of pain, and he recommends combined treatment by a radiotherapist and a physical therapist as does Baker.<sup>413</sup> He found that changes in the sedimentation rate after treatment are not always parallel to clinical improvement.

Dassen and Rospide<sup>415</sup> examined 12,000 roentgenograms of the spine taken to detect conditions other than spinal lesions. They report typical lesions of spondylarthrosis in 140, or 1.6 per cent. Of these, 100 roentgenograms belonged to patients whose recorded clinical history did not show any relation between the observed spondylarthrosis and pains of any kind.

They believe that the evolutive development of spondylarthrosis runs parallel with that of arteriosclerosis and both show the same humoral modifications.

Oppenheimer<sup>416</sup> reports 4 cases of "paravertebral abscesses associated with Strümpell-Marie Disease." He states that the 4 cases had certain points in common. The disease was chronic and began with pain and stiffness in a definite part of the back or neck. In the course of several years, the pain tended to subside and the stiffness increased, but the symptoms remained confined to the region originally affected. Abscesses in the soft tissues of the back or neck were present at the level of but not below the involved vertebrae. Roentgenograms disclosed ankylosing arthritis of the apophysial joints at the level of the abscess of the soft tissue, with ossification of the vertebral ligaments but without

414. Hilton, G.: Some Observations on the X-Ray Treatment of Ankylosing Spondylitis, *Proc. Roy. Soc. Med.* 36:608-610 (Sept.) 1943.

415. Dassen, R., and Rospide, P. C.: Asymptomatic Spondylarthrosis and Its Frequency, *Medicina, Buenos Aires* 3:275-286 (April) 1943.

416. Oppenheimer, A.: Paravertebral Abscesses Associated with Strumpell-Marie Disease, *J. Bone & Joint Surg.* 25:90-96 (Jan.) 1943.

412. Collins, H. L.: An Unusual Fracture of Second Cervical Vertebra, *J. Kansas M. Soc.* 44:253-254 (Aug.) 1943.

413. Baker, L. D.: Ankylosing Spondylarthritis, *South. M. J.* 36:180-184 (March) 1943.

destruction of bone, which might account for the abscesses.

He believes that the possibility cannot be entirely discarded that the apophysial arthritis observed in these patients was the result of the persistent hyperemia, which accompanied the chronic purulent infection of the paravertebral soft tissues.

[ED. NOTE.—This is an interesting report, but the author's use of the term "paravertebral abscesses" is confusing. Evidently there was no roentgen evidence of an abscess next to the vertebral column, which is the usual concept of a paravertebral abscess, but the abscesses reported were in the skin and soft tissues of the neck or back. This paper seems to show, as indicated by Goldfain,<sup>417</sup> that ankylosing spondylitis may be caused by infection, the type of which may or may not be determined.]

Dobelle<sup>418</sup> presents a case of spondylitis complicating undulant fever in which spinal fusion was successfully employed and in which brucellin proved to be a most valuable adjunct. He urges early differential diagnosis in cases in which the clinical picture is similar and states that although 64 cases of spondylitis complicating undulant fever have been reported in only 3 was spinal fusion performed. Roentgenograms had shown rapidly progressive destruction of the bodies of the third and fourth lumbar vertebrae, and after fusion of an area from the third to the fifth lumbar vertebra followed by brucellin therapy subsequent films showed solid fusion and healing of the involved vertebrae.

[ED. NOTE.—Evidently the fusion was of definite value in this case, in view of the progressive destruction of the vertebral bodies, but from other reports it does not seem indicated in all cases of brucellosis spondylitis. The author states, "At the time of surgery, if the posterior element involvement had been suspected, fusion would have been extended to the sacrum." This again brings up the question of whether all fusions extending down to the fifth lumbar vertebra should be extended to the sacrum. In view of the frequency of instability in the lumbosacral joint and the frequent need for fusion of this joint plus the added strain on it if the vertebrae above are fused, it seems likely that many, if not all, fusions which include the fifth lumbar vertebra should be extended to the sacrum.]

417. Goldfain, E.: Chronic Brucellosal Type of Ankylosing Spondylitis, *J. Lab. & Clin. Med.* 28:1226-1231 (July) 1943.

418. Dobelle, M.: *Brucella Spondylitis*, *Am. J. Surg.* 60:130-133 (April) 1943.

Goldfain<sup>417</sup> reports a study of 18 cases of ankylosing spondylitis, in 5 of which cutaneous, agglutination and opsonic index tests gave positive results for brucellosis. He points out that ankylosing spondylitis is a symptom complex and believes that the cause may be an infection which can be either determined, as in these 5 cases, or not determined in the present stage of knowledge. Chronic brucellosis, like syphilis or tuberculosis, may reveal itself in different ways, one complication being a rheumatoid type of arthritis, which when limited to the spine presents the symptom complex of ankylosing spondylitis. In 3 of the cases improvement resulted with general medical measures and bacterin therapy, in 1 the response was only moderately favorable and in the fifth the response to bacterin therapy was poor.

*Scoliosis and Other Deformities.*—Shaw<sup>419</sup> reviews the problems of care after thoracoplasty. He points out that the modern extrapleural thoracoplasty is an effective measure of collapse for the closure of tuberculous cavities, but most reports on the results deal with its main object, closure of the cavity and conversion of the sputum. He feels that certain sequelae of thoracoplasty must be evaluated in a full appraisal of the end results of this procedure. He discusses the chief mechanical defects of thoracoplasty that may contribute to invalidism or disability, pain in the chest or shoulder, scoliosis and limitation of motion of the shoulder. He states that pain following thoracoplasty may be constant or present only on motion of the shoulder. The constant pain is often caused by contraction of the underlying fibrotic lung or thickened pleura or to intercostal neuritis due to pinching of the nerves by the costal stumps, while pain present only on motion of the shoulder is usually due to contact of the scapula with some bony prominence.

The author discusses resection of more ribs or partial resection of the scapula for relief of pain in the scapula due to impingement of the scapula on the ribs and describes his attempt to prevent scoliosis. He states:

Four muscles that connect the cervical vertebrae with the upper ribs have their lower attachments released at the time the first stage of the thoracoplasty is performed. These are the three scaleni and the serratus posterior superior muscle. When they are released their antagonists on the opposite side of the neck are unopposed and thus draw the head and neck to the opposite side giving the characteristic wry neck present following thoracoplasty. . . . During the past two years the author has reattached the posterior scalenus

419. Shaw, R.: Post-Thoracoplasty Care: Scoliosis, Pain and Rehabilitation, *Dis. of Chest* 9:327-333 (July-Aug.) 1943.

and serratus posterior superior muscles to the sacrospinalis muscle at the time of the first stage in an attempt to partially correct this imbalance. It has not been found technically feasible to reattach the anterior and middle scaleni muscles since no supporting structure was readily available for an anchorage. It is too early to report accurate clinical results, but this procedure has promise in helping to reduce scoliosis following extrapleural thoracoplasty. It may be found that scalenotomy on the opposite side following completion of the thoracoplasty will correct severe scoliosis. To my knowledge this has not been done but it is certainly a logical procedure and deserves a trial.

The author believes that the convalescent period after thoracoplasty should be a minimum of six months.

[ED. NOTE.—This is a good review of the problem of thoracoplasty and its complications. The author's attempt to partially correct the muscle imbalance and limit the development of scoliosis by reattaching the posterior scalenus and serratus posterior superior muscles to the sacrospinalis muscle at the time of the first stage and his suggestion of scalenotomy on the opposite side to correct or prevent severe scoliosis may well be of value in certain cases. Perhaps the maintenance of proper position of the spine either straight or flexed to the side of the thoracoplasty should be stressed more in the postoperative care, especially in children. It might also be mentioned that the author does not discuss the transplantation of the lower angle of the scapula within the thoracic cage following upper thoracoplasty to obtain added compression of the lung and to overcome the difficulty of impingement of the scapula on the rib, so well described by Leahy,<sup>420</sup> in 1940. Leahy reports 50 cases, and I have seen a number of these operations demonstrated showing excellent results, with the patients obtaining remarkable function, even on lifting heavy objects. Leahy's excellent paper evidently has not received the attention it warrants and should be included in any review of post-thoracoplasty problems.]

Cobb<sup>421</sup> discusses the treatment of scoliosis and some of his observations after the study of over 2,000 cases since 1934. He gives an outline for the etiologic classification of scoliosis and one for the study and treatment of scoliosis. He lists the indications for operation and outlines the operative treatment and follow-up examination. He stresses the importance of careful study and believes that rest in recumbency is the only nonoperative treatment which seems to be of any value in arresting progressive

curvatures, though this does not decrease curve. In conclusion he states:

1. Structural scoliosis is a self-limited condition.
2. Most curvatures stop progressing spontaneously requiring no treatment.
3. Practically all idiopathic curvatures stop progressing at or before age 15.
4. Relatively few curvatures increase to sufficient degree to require treatment.
5. Spine fusion operation is the only treatment present which will prevent increase and maintain correction.
6. Bed rest is the only non-operative treatment which seems to arrest some progressing curves—but does not obtain improvement.
7. The main problem is in determining which curves will require operation; especially before age 15 when the curve is increasing.
8. Indication for fusion depends on etiology, age, progress, deformity, etc.

[ED. NOTE.—It seems worth while stressing the importance of rest, especially in the treatment of idiopathic scoliosis, and the importance of careful study to avoid unnecessary operation in patients under 15 years of age when the curve is not increasing and not severe. In many patients with definite curvatures at the age of 12 and 13, the curves do not increase and do not need operative correction, although this is not generally known.]

*Referred Pain.*—Martin<sup>422</sup> discusses radicular pain and its physical treatment. His review of the literature does not include the more recent articles on this subject in the past few years which have been reviewed in this survey, including that on the so-called viscerospinal syndrome. This is a good article for a general review of the subject and the medical and physical treatment, but it merely outlines the orthopedic treatment. It stresses the importance of diagnosis and also the importance of conservative treatment in many cases.

Although it is often difficult to distinguish definitely referred pains of visceral origin from those of somatic origin, there are certain characteristics of radicular pain or referred pain of somatic origin that may be of value in ruling out pain of visceral origin. 1. The history is usually not typical of any visceral disease. 2. The pain may have an indefinite localization somewhere along the distribution of the involved nerve. 3. The pain may be aggravated by motion and postural changes, by flexion of the neck or by straight leg raising. 4. The pain may be precipitated or aggravated by increased intra-abdominal and intrathoracic pressure, as in coughing, sneezing and straining. 5. There is usually an absence of deep tenderness. 6. There is usually no tenderness along the involved nerve. 7. Local tenderness may be present over the spinous processes or foramina. 8. The pain may be preceded or accompanied by paresthesia. 9. Hyperesthesia and hyperalgesia of the skin and subcutaneous tissues may be present, and hypo-esthesia and hypalgesia may develop in the later

420. Leahy: Transplantation of the Lower Scapula Within the Thoracic Cage Following Upper Thoracoplasties, *Surgery* 7:875-882 (June) 1940.

421. Cobb, J. R.: Treatment of Scoliosis, *Connecticut M. J.* 7:467-471 (July) 1943.

422. Martin, G. M.: Radicular Pain and Its Physical Treatment, *M. Clin. North America* 27:994-1000 (July) 1943.

stages. 10. Reflexes may be diminished or absent. 11. Motor symptoms are more common than they are in visceral disease.

His summary is as follows:

Various lesions of the spinal column cause pressure on the roots of the spinal nerves. This results in radicular pain which is at times considered due to visceral disease. Correct diagnosis depends on cognizance of the radicular syndrome, careful history, physical and neurologic examinations and roentgenologic examination of the spinal column. Many of the early mechanical lesions may be treated in part by simple physical therapeutic methods while more advanced and severe lesions will require neurologic and orthopedic procedures.

[ED. NOTE.—The author points out that "it is remarkable how rarely a well developed scoliosis causes radicular pain." However, he states that "in cases in which radicular pain is due to a functional scoliosis without serious organic change, and the degree of scoliosis is not severe enough to require surgical fusion, the patients also may be treated with corrective exercise." The author implies that functional scoliosis might require fusion and states: "A brace or spinal fusion may be necessary in a case of severe or rapidly progressive scoliosis that is either functional or organic." It is obvious that a spinal fusion is not necessary for functional scoliosis itself, though it may be necessary to stabilize a spine when the pain due to instability is causing functional scoliosis.]

In a study on the effects of injections of procaine hydrochloride on simulated visceral pain, Young<sup>423</sup> reports the results of fifty-six injections of procaine hydrochloride into the deep paravertebral muscles of 26 patients with spondylitis. All these patients had simulated visceral pain, and the symptoms could be reproduced by pressure on the muscles lateral to one or more vertebrae and by torsion or hyperextension of the spine at the same level. They were divided into two groups, those with and those without visceral disease, and in both groups the results were uniformly good. The author believes that these were probably due to the dissolution of a vicious reflex cycle, though he points out that a complete explanation of the prolonged therapeutic results cannot be offered. He feels that this method has been so effective, so simple and so free from complications that its continued use is indicated.

*Posture.*—In a physiologic study of the vertical stance of man, Hellebrandt and Franseen<sup>424</sup> give a review of the literature, with three hundred

and seven references, and discuss thoroughly the physiologic factors in posture.

They point out that the evolution of the biped stance has been marked by a narrowing of the base of support and a progressive elevation of the center of gravity of the body as a whole. Both militate against stability. They stress the point that "the vertical posture also imposes an hydrostatic handicap which encroaches enough on the adequacy of the circulation to make man in the upright stance vulnerable to peripheral circulatory collapse." They feel that the numerous difficulties seemingly attributable to a change from quadruped to biped standing, which are interpreted by some as signs of extreme inadequacy of adaptation, are counteracted easily in the majority of normal men by compensatory mechanisms, which automatically cancel the apparent mechanical disadvantages of the change.

They point out:

The relative importance of vasoconstriction, cardiac acceleration, augmentation of respiration, skeletal muscle tone, and insensible contraction, to the maintenance of an adequate circulation during standing in man, has not been determined.

They feel that it has yet to be shown that posture is a decisive etiologic factor in the failures in adaptation to vertical stance, which occasionally are so acute as to cause syndromes of pathologic significance.

[ED. NOTE.—This is an excellent article, which should be read by those interested in posture, as it cannot be adequately summarized. It has a complete bibliography on the subject.]

Fries and Hellebrandt,<sup>425</sup> in studying the influence of pregnancy on location of the center of gravity, postural stability and alinement of the body, point out that aside from studies made on changes in weight and alterations in the pelvic joints few, if any, consecutive observations have been reported on the readjustments of the parts of the body as they accrue in pregnancy and regress during puerperium. They recorded postural adjustments of the pregnant woman by means of serial biplane photographs synchronized with observations on the center of gravity and report an almost exact return to the original values of three factors: body weight, height of the center of gravity and eccentricity of stance.

In the 2 subjects studied there appeared to be an unexpected slight change in the lumbar region of the spine, the "exaggerated lumbar curve," which is commonly thought to occur, not being prominent. The curves in both sub-

423. Young, D.: The Effects of Novocain Injections on Simulated Visceral Pain, *Ann. Int. Med.* **19**:749-756 (Nov.) 1943.

424. Hellebrandt, F. A., and Franseen, E. B.: Physiological Study of the Vertical Stance of Man, *Physiol. Rev.* **23**:220-255 (July) 1943.

425. Fries, E. C., and Hellebrandt, F. A.: The Influence of Pregnancy on the Location of the Center of Gravity, Postural Stability, and Body Alinement, *Am. J. Obst. & Gynec.* **46**:374-380 (Sept.) 1943.

jects appeared almost parallel. They believe that the data indicate that the major counterbalancing adjustments are made by elevating the head, extending the cervical portion of the spine, stabilizing the knee joint and leaning backward from the ankle.

[ED. NOTE.—This is an interesting study but is based on only 2 subjects and may not represent the findings in a larger series. Also there may be more definite changes in the vertebrae than would be suspected from the photographs, and lateral roentgenograms might show more of a change, especially in the lumbar area. It is well known that in cases of scoliosis subsequent photographs or silhouettes may show improved posture, but the roentgenograms may show a decided increase in the curve, which is not detected in the photograph.]

*Fractures and Dislocations.*—Dingman<sup>426</sup> describes a new splint for cervical fractures and dislocations, with illustrations to demonstrate its construction and use and roentgenograms to show the reduction obtained in 1 case in which this splint was used. The splint was devised primarily to insure the same transportation of patients with fractures and dislocations of the neck, and the author states that it "combines the principles of traction, extension and immobilization." The advantages of the splint are that the amount of traction can easily be measured with an ordinary scale, unobstructed anteroposterior and lateral roentgenograms can be taken and the countertraction pushing down on the shoulders simplifies visualization of the seventh cervical vertebra.

[ED. NOTE.—I have seen this ingenious splint demonstrated, and it seems to solve many of the problems of transportation and care in the difficult cases. While traction on the skull will probably still be necessary for adequate reduction in some cases, application of this splint will probably be adequate treatment in many of them. It probably could be used with skeletal traction also.]

Hook and Mazet<sup>427</sup> review the different methods of treatment of fractures of the cervical portion of the spine and favor the use of skeletal traction with Crutchfield tongs. To make the patients ambulatory with the tongs in place, especially if evacuation is necessary, they devised an ambulatory traction apparatus. It consists of a steel strap and is incorporated in a

plaster jacket. The steel strap extends up over the head, with several holes in the top end so that the tongs can be secured to it. To take up the slack incident to variations in tension produced by changes in position, they inserted a coil spring between the strap and the tongs. They found that it was important to extend the jacket up on the neck posteriorly as high as possible and over the shoulders to secure firm fixation of the bar. The steel strap must be strong and not too springy.

The authors present 2 cases in which this method of treatment was used. While they do not advocate it as a routine method of treatment, they feel that it has a place for patients for whom evacuation is necessary and reduction cannot be maintained in a plaster collar or for elderly or plethoric persons for whom prolonged recumbency is contraindicated.

[ED. NOTE.—This is an interesting method of treating fractures of the cervical portion of the spine and will probably be of definite value in selected cases.]

Lyon<sup>428</sup> presents a case of so-called backward displacement of thoracic and lumbar vertebrae, with a discussion of the causes, age factor and treatment and of the mechanism of backward displacement of one vertebra on another. He states:

The exciting cause of backward displacement is seen in dorsoventral tears and fissures of the intervertebral disk situated below the shifted vertebrae, which causes loosening of the structure of the disk. Attention is directed to the prominent part played by the posterior longitudinal ligament, the participation of which has not been given much consideration up to the present. It is not until this ligament yields its pressure that a vertebra can be thrown backwards.

[ED. NOTE.—While the author may be correct in his explanation, the case presented certainly does not prove his point. The roentgenograms show wedging of the twelfth dorsal vertebra, some osteoporosis but no evidence of real backward displacement. They demonstrate compression of the twelfth dorsal vertebra with compensatory backward tilting of the vertebrae below.]

Davis,<sup>429</sup> in a paper on new aspects of spinal injuries, records points concerning the treatment of spinal injuries on which general agreement has been reached, points on which there still exists considerable divergence of opinion and a number of new aspects which may be considered addenda to the general subject of spinal injuries.

426. Dingman, P. V. C.: A Splint for Cervical Fractures and Dislocations, *J. Bone & Joint Surg.* 25: 473-476 (April) 1943.

427. Hook, F. R., and Mazet, R., Jr.: An Ambulatory Traction Device for Treatment of Fractures of Cervical Spine, *U. S. Nav. M. Bull.* 41:207-213 (Jan.) 1943.

428. Lyon, E.: Backward Displacement of Thoracic and Lumbar Vertebrae, *J. Internat. Coll. Surgeons* 6: 490-495 (Sept.-Oct.) 1943.

429. Davis, A. G.: New Aspects of Spinal Injuries, *Arch. Surg.* 46:619-634 (May) 1943.



The author stresses the importance of careful study to discover any cracks or dislocations of a posterior vertebral arch, pointing out that wherever a double shadow of a vertebra appears dislocation of one articular process must be expected and that oblique roentgenograms taken at an angle of 30 to 40 degrees are more likely to exhibit fracture lines in the articular processes than lateral roentgenograms.

[ED. NOTE.—This is an excellent article and stresses the importance of involvement of the posterior elements in spinal injuries, which still seems to be not generally appreciated.]

*Lesions of Disks.*—Stump and Narins<sup>430</sup> report a case of injury to an intervertebral disk during spinal puncture in a 12 year old girl with meningitis. Roentgenograms taken after the puncture showed collapse of the disk between the third and the fourth lumbar vertebra. Subsequent films showed a further thinning of the disk with increased opacity of the lower portion of the third lumbar body and the upper portion of the fourth lumbar body, which was considered indicative of an inflammatory process. They believe that in this case an inflammatory process developed after the penetration and perhaps after the direct inoculation of the disk with a needle for spinal tap.

[ED. NOTE.—While injuries to the intervertebral disk during spinal puncture have been previously reported and reviewed in this survey, it is perhaps well to stress this as a complication which is being noted more frequently.]

Bucy and Spiegel<sup>431</sup> report an unusual complication of the intraspinal use of iodized oil. The patient had had a spinal fusion in the lumbosacral area in April 1937 and an intraspinal injection of iodized oil in March 1938, after which fluoroscopy revealed some of the oil lodged at the level of the eighth thoracic vertebra. Progressive symptoms of involvement of the spinal cord developed at that level. In February 1942 lumbar puncture revealed an almost complete spinal block. At operation two collections of encysted iodized oil in the subarachnoid space and a thickened arachnoid membrane were found and removed. They believe that this patient had localized adhesive arachnoiditis at the level of the eighth thoracic vertebra prior to the injection, which caught and held some of the oil.

[ED. NOTE.—This is another example of encysted iodized oil after injection for localization

of spinal lesions. It should be another warning against the use of iodized oil and stresses the importance of removing the oil either by aspiration or by operation. Evidently more and more orthopedic surgeons are finding fewer indications for the intraspinal injection of iodized oil, and many do not even use it for the usual suspected lesions of disks. Many feel that in most cases the lesions can usually be adequately localized clinically or by roentgen rays without the use of intraspinally injected contrast mediums.]

In an excellent article on intraspinal administration of colloidal thorium dioxide Nosik<sup>432</sup> briefly reviews the literature on the use of this material and in a short and concise outline gives the method of preparation, the technic for making the myelogram and the treatment after myelography. He also discusses the advantages and disadvantages of intraspinally injected contrast mediums and the advantages of thorium dioxide. He reports 100 cases and states:

In the positive myelograms confirmed by operation the diagnostic accuracy of thorotrast is 93.97 per cent (error of 6.17 per cent). In the negative myelograms which were explored on clinical grounds alone, the diagnostic accuracy of thorotrast was 89.97 per cent, the error 11.1 per cent.

The author's conclusions are as follows:

The search for the ideal intraspinal contrast medium is not ended. By instituting the technique described here, we have eliminated most of the undesirable features of thorotrast. A medium has not yet been found which will outline every structure within the subarachnoid space, sharply define its every ramification, and then be spontaneously absorbed and eliminated after it has served its purpose.

[ED. NOTE.—Any one wishing to use colloidal thorium dioxide with this method will find this article of great value.]

Oppenheimer<sup>433</sup> discusses the pathologic features, the clinical manifestations and the treatment of lesions of the intervertebral disks. On the basis of a series of 826 cases of lesions of disks observed during the last eight years, of a control series of 200 cases in which no symptoms existed and of another control series of 100 cases in which there were symptoms suggestive of lesions of disks, he attempts to ascertain whether correlations can be established between the clinical and the anatomic findings and whether principles can be defined by which treatment may be directed. The author discusses the pathologic features, dividing the common lesions into those caused by rupture and those due to degeneration.

430. Stump, J. P., and Narins, S. A.: Intervertebral Disc Injury During Spinal Puncture, U. S. Nav. M. Bull. 41:400-403 (March) 1943.

431. Bucy, P. C., and Spiegel, I. J.: An Unusual Complication of the Intraspinal Use of Iodized Oil, J. A. M. A. 122:367-369 (June 5) 1943.

432. Nosik, W.: Intraspinal Thorotrast, Am. J. Roentgenol. 49:214-218 (Feb.) 1943.

433. Oppenheimer, A.: Development, Clinical Manifestations and Treatment of Rheumatoid Arthritis of Apophyseal Intervertebral Joints, Am. J. Roentgenol. 49:49-76 (Jan.) 1943.



### He found:

The incidence and severity of the clinical manifestations were not proportional to the degree of disc thinning, as measured by the width of the intervertebral space. No correlation could be established between any of the clinical signs and symptoms, on the one hand, and the degree of disc thinning on the other.

The author also states:

... that lesions of the discs cause symptoms felt in the periphery rather than in the spine and that, in the presence of disease of the spine, pain and rigidity of vertebral regions are caused in most cases by involvement of the apophyseal joints. Since disc lesions induce arthritis of the apophyseal joints in only about one fifth of the cases, symptoms felt in the spine are not common, and the vertebral origin of peripheral pain easily escapes recognition.

He believes that such signs as pain in the back induced by sneezing and coughing are certainly not typical of rupture of a disk and may be observed in the presence of various other lesions of the vertebrae. He found that clinical signs suggestive of lesions of disks were due to some other disease in about 10 per cent of the cases and that their connection with a demonstrable lesion of a disk was questionable in at least another third, so that roentgenographic demonstration of a diseased disk does not prove the discogenic origin of the symptom, and in about two thirds of the cases certain clinical manifestations were probably due to lesions shown roentgenographically.

For treatment the author favors positions and exercises to relieve pain but has been dissatisfied with the use of braces and traction. In 582 cases roentgen ray therapy was used for the control of backache and radicular nerve pain, and, although many authors believe its effects are highly questionable, he believes that the value of this mode of treatment is not generally recognized. The best results of roentgen ray therapy were noted for patients with trophic disturbances of the skin, muscles and bones in the peripheral segments corresponding

to the involved disk, and he reports the disappearance of severe lesions within a number of weeks.

In conclusion, the author states that no matter what is the cause of the injury and degeneration flattening of the disk leads to narrowing of the corresponding intervertebral spaces, associated with displacement of articular processes, narrowing of the neural foramen and abnormal contact between vertebral bodies and that the clinical manifestations depend on these secondary alterations rather than on the degree of thinning of the disk. He believes:

The signs and symptoms of radicular neuralgia and neuritis are often indistinguishable from those of myalgia, peripheral arthritis, bursitis and pain referred from diseased viscera. Moreover, in the age group in which the incidence of disc lesions is highest, involvement of joints, bursas and viscera is also common. The difficulties encountered in recognizing disc lesions are chiefly caused by these diagnostic limitations. When disc lesions coexist with other diseases that are known to induce peripheral pain, the differential diagnosis can be made only after exhaustive clinical studies are made.

The author reports satisfactory results with conservative treatment in 75 per cent of the cases.

[Ed. NOTE.—It seems desirable to stress the importance of adequate studies in all cases of pain in the back, neuritis, sciatica, etc., especially to rule out the possibility of diseased viscera and other nonorthopedic problems. There is a tendency for many physicians, including orthopedic surgeons, to rely on inadequate histories, incomplete physical examinations and too few consultations with other specialists and resort to routine treatment consisting of physical therapy, supports or operation, when the major lesion may be nonorthopedic. Apparently it is not uncommon for the busy orthopedic surgeon to overlook the general medical picture and treat the patient orthopedically for pain in the back due to some visceral lesion, such as a gastrointestinal malignant growth.]

(To Be Continued)

## GENETIC ASPECTS OF THE CANCER PROBLEM

### PRELIMINARY REPORT ON A SURVEY OF CONSTITUTION AS RELATED TO CANCER

FRITZ BLANK, M.D.

NEW YORK

#### FOREWORD

F. A. E. CREW, M.D., F.R.S.

This survey of the biologic background of cancer is the first major attempt by this institute (the Bureau of Human Heredity) to present the results which can be achieved through the clearing house method. It has been made possible by international collaboration between the Bureau of Human Heredity and the Genetics Laboratory of Ohio State University. Both institutes are foci of much friendly cooperation between individual workers and numerous institutes.

It is worth noting that the work was begun in London in 1940—the period of constant day and night air raids—and (owing to that fact) was transferred at short notice to the friendly institute which has fathered its completion. Enemy action caused three hundred references to be lost in transit, which were later replaced from duplicates.

The Bureau of Human Heredity has been evolving the mechanism for such work as this on the most fully international lines since it opened in 1936.

There are three main functions of the clearing house, or information center:

1. References—that is, an extensive bibliography—are collected.
2. Added to these are fully indexed data collected from separates and information sent in by individual research workers, approached by a wide correspondence plan.
3. Information on the preceding data is furnished on request, so that the needs of the individual enquirer are dealt with. (Publication does not form part of the work, since new data, arriving steadily, modify previous findings.) Information rests on comparative analysis of the data collected.

This preliminary report was submitted and approved by the Council of the Bureau of Human Heredity in London and the Genetics Laboratory, Department of Zoology and Entomology, Ohio State University, under the joint auspices of which the survey of Constitution in Cancer was conducted.

Analysis, moreover, entails the collection of papers on diagnosis and case histories; further, careful definition of terms is required, which results in an impressive body of information on nomenclature—this has now been developed as a Synonyma Index. It throws light both on the data and on the usage of different schools; differences are observed not only between one part of the world and another but often within the same country. The crux of the work thus briefly described is the method of the cross reference index, best compared to a great sorting machine. The desideratum was outlined early by R. A. Fisher and J. B. S. Haldane in consultation. It works well. Three thousand sections on constitution and traits were already available when Dr. Blank began the cancer collection. Points in the present survey can be set against a further fifteen hundred odd.

Many papers on heredity in cancer called for special treatment and could not be dealt with apart from comprehensive study of the biologic background, including variations of constitution, as viewed by research workers. Some correlation with medical observations on case histories has been possible. This preliminary survey aims at assessing the knowledge (as it stood in 1941) on interaction of organic and inorganic forces found in various forms of neoplastic growth, including malignant lesions. It covers much of the literature between 1900 and 1941, with data from about four thousand papers. Its value lies in the juxtaposition of the various lines of attack on the cancer problem, which is thus at least a start to clearing up misapprehensions; the practicing physician will find hints from the broad outlines of different familial types of susceptibility. Such may well be of use in the constant search for early diagnosis and ever earlier preventive treatment—the choice of therapeutic measures based on such a datum may also well be envisaged.

In this connection it is interesting to note the importance of comparison of the outlook on cancer with the data in the cross reference sections of the clearing house. Constitutional

traits are in many instances verifiable as genotypic or simple phenotypic. Thus a good deal that the specialist in cancer would view as speculative can be shown here to be factual from data so accumulated that they can be easily found.

One comment is permissible: The emphasis on mendelian formulas which dominates so much of the experimental work in genetics which has been surveyed will almost startle a reader conversant with papers of 1944. Now the interaction of gene with gene is coming increasingly to the fore, so that the picture of "modifiers," "degrees of penetrance" and so on, superimposed on the mendelian picture, has blurred the old outlines beyond recognition. The biologic-genetic entities, however, stand and to our thinking justify this modest attempt within the framework of the new "machine," the information center. The summarized genetic findings are not the less important for presenting no surprises.

The myth of hereditary cancer is disposed of. Geneticists are more and more aware in other fields of the fact that hereditary makeup controls type of constitution, in other words individual variations in physiologic function. Hence the statement in the early pages of this survey—"These and many other pedigrees and observations leave little doubt as to the importance of hereditarily determined factors" as precursors of the disease, as seen in localization of growth and type of neoplasm.

This may be stated in another way: Hereditary immunity, partial or complete, may be reckoned with, while proneness to benign and malignant tumors unquestionably exists.

*Cancer Soil.*—There is evidence from many sources that carcinogenic agents react differently on various types of constitution. This is the obverse of the foregoing statement and, again, would be expected by those versed in physiologic genetics. An illuminating point may be gleaned here, namely, that certain types respond quickly to diverse kinds of irradiation. Another type appears to be mainly due to hormonal imbalance, which prepares the body for benign and/or malignant tumors. Fortunately, data give at least a rough guide as to means of differentiating between the various types of the disease.

*Other Diseases.*—It is significant that certain hereditary diseases appear frequently as precursors of neoplastic growth and malignant lesions. Careful observation by physicians should soon add many facts under this heading. Here the clearing house may have special importance. Practitioners by contributing their observations to the center will do much to accelerate accumulation of knowledge of practical value for their colleagues and humanity.

The present opportunity for shared work with another organization fulfils our general aim of mutual worldwide activities and has given us in London the keenest satisfaction. We record our sense of gratitude to those who have turned this cherished dream into reality.

#### PRELIMINARY REPORT

Few subjects can present such a welter of complications, for research worker and physician alike, as that of tumors of man in relation to heredity. The groundwork has been covered in many apparently unrelated fields, and workers in botany, zoology, physics, chemistry, statistics and genetics have accomplished an enormous amount in their several lines. Their observations, however, appear in special journals, and the literature is scattered and not easily available, so that workers in one field are unlikely to be acquainted with results in others; while physicians, who have the best contact with actual cases and who could thus contribute highly valuable material, are frequently out of touch with research on the genetic aspects of cancer. Even when a physician has been led, through his observations on individual patients, to recognize the importance of hereditary factors in clinical histories, he is unable to follow them up readily, particularly in the case of cancer, because of the obstacles in the way of understanding the biologic complex that is involved. One cannot even guess how many valuable data may be lost for these reasons.

#### SURVEY OF CONSTITUTION IN CANCER

It was the aim, therefore, of the Survey of Constitution in Cancer: first, to collect the relevant data; then, to coordinate and cross index them according to the system followed by the Bureau of Human Heredity in its studies of genetic traits, and, further, to compare the validity of and collate the results in order to evaluate the real status of knowledge in this field and to examine and define areas demanding further exploration.

The accompanying form, devised to cover all the fields under survey, has proved satisfactory in handling the huge quantity of material examined, amounting to many thousands of separate references.

The work is by no means complete, nor indeed can it be ended while research in cancer continues. Nevertheless, at the stage now reached it is possible to present a preliminary summary of the role of genetics in cancer research, covering the period between 1900 and 1941. The object is not an exhaustive enumeration of the items but the coordination of developments and trends.

in the several lines of inquiry, often seemingly remote from genetics, from the point of view of both genetics and the practice of medicine.

#### Work Sheet Used in Survey of Constitution in Cancer

No.

Author:

Title:

Reference:

Statistics	Man,	Animals	
Racial differences			Plants
Predisposition, general			
" localized			
" special types			
Cancer families	Spontaneous, induced, transplanted		
Twins	Hereditary, acquired, indeterminate		
Conjugal cancer	Cancerogenic agents		
Congenital "	irritants		
Multiple tumors	chemical		
Cell processes			
chromosomal	mechanical		
extrachromosomal	trauma		
Age, sex	actinic rays		
Body type, blood group	micro-organisms		
Pigmentation	parasites		
Endocrine system			
Blood-lymph "			
Nervous "	Occupational		
Metabolism: body	Analysis:		
" tumor	positive		
Lactation	negative		
Pregnancy	indeterminate		
Fertility			
Developmental defects	Mode of transmission		
Precancerous conditions	Extrachromosomal factors		
Coexisting diseases			
Infection	Generalla		
Lowered resistance			
Immunity	Bibliography		
Environmental factors			

The selection and arrangement of material in the summary were necessarily limited by this purpose, and failure to mention the work of any author does not reflect on its importance in any way. The same fact accounts for the small number of references cited here out of the extensive collection in the archives of the Bureau of Human Heredity. Publication of the complete bibliography has been prevented by war conditions, but it and the final report on the survey will follow as soon as circumstances permit. In the meantime information about the material on file will be made available on request to interested students.

#### ROLE OF GENETICS IN CANCER RESEARCH

At the beginning of the twentieth century, research on cancer, which had hitherto been largely descriptive, entered on a wholly new phase, as a result of four factors: (1) the re-

discovery of the laws of genetics; (2) the study of spontaneous and transplantable tumors in animals from the standpoint of heredity; (3) the study of cancerogenic agents, which opened the way for experimental study of induced tumors biologically controlled, with research on hormones an especially important section; (4) an increased knowledge of the biologic connection between irritants, and differences in individual reactions. How are these factors connected, and why is each one important for the study of the cancer problem?

Evidently no proper approach to the problem of cancer and heredity could be made and of course no solution could be found without knowledge of the principles governing hereditary transmission in general.

It was only in 1900 that these principles, the laws of genetics, which were discovered originally by the monk Gregor Mendel as early as 1866, were rediscovered by three investigators working independently of each other: Hugo de Vries, in Holland; Carl Correns, in Germany, and B. Tschermak, in Austria.

Since then a new branch of science has been developed, the importance of which cannot be better demonstrated than by giving facts about the role which genetics plays in modern cancer research. Indeed, the place of genetics in this particular field affords an excellent example of the value and aim of the study of heredity in general; certainly no serious discussion of the cancer problem could be carried out were the subject not included.

For the discovery of several nonspecific cancerogenic agents has not solved the problem; nor would the discovery of a prime causative agent, such as a bacillus or a virus, make everything clear. In either case the striking individual differences in susceptibility and immunity to malignant tumor growth would remain unexplained, as would the connection between such individual differences and variety or type of constitution.

But constitutional types in themselves cannot be easily defined or explained; nor is it easy to answer the apparently so simple question, "Is hereditary transmission involved as a major cause in a so-called cancer family?"

Evidence from several lines of approach may be consulted, of which at least five are considered in this review: statistics on cancer, histories of families, study of twins, experimentation on animals and response to cancerogenic agents.

#### I. STATISTICS ON CANCER

An unusually high incidence of cancer in a given family, or even in a number of families

within a community, does not of itself constitute statistical evidence for the heritability of cancer. For, by the law of probability, cancer is bound to occur with exceptional frequency in a certain number of families simply because of its high incidence in the general population, where it accounts for 1 out of every 10 deaths.

As early as 1913 Bashford estimated the number of deaths due to cancer that may occur in families of various sizes without warranting any assumption that hereditary factors are involved. The accompanying table, based on Bashford's

*Probability of Multiple Cancer Cases Without Assuming Hereditary Tendency\**

No. of Cancer Deaths in Family †	Per 100 Families of 6 Members, viz. 3 Men, 3 Women	Per 100 Families of 8 Members, viz. 4 Men, 4 Women	Per 100 Families of 10 Members, viz. 5 Men, 5 Women
None.....	47	36	28
One.....	38	39	38
Two.....	13	19	23
Three or more.....	2	6	11
	100	100	100

\* After Bashford (1913-1914) as cited by Cramer.<sup>1</sup>  
† All deaths before the age of 35 are excluded.

figures as cited by Cramer<sup>1</sup> in his paper on statistical investigations of cancer, published in 1937, indicates how frequently death may be expected to occur among families of six, eight and ten members surviving their thirty-fifth year. From this it is clear that a steady increase in the number of deaths due to cancer will occur with increasing size of a family, so that the proportion of families with no such deaths drops from 47 deaths in 100 families of six members, to 36 in 100 with eight members and to 28 in 100 families of ten members. The incidence of same for the three sizes. But multiple deaths increase sharply, with the ratio of 2 deaths per family going from 13 to 19 to 23 families in 100; while 3 or more deaths from cancer may be expected in 2 out of 100 families with six members, in 6 of those with eight and in 11, or more than a tenth, of the families with ten members.

Thus, a high incidence of cancer in a single family means nothing so far as the problem of heredity and cancer is concerned unless the conditions are checked by careful statistical methods. But here one encounters difficulties even greater than those usually faced in examining hereditary traits in man, because the family histories of large groups are notably unreliable with regard to cancer. To lack of accurate knowledge about

cancer among ancestors and mistakes of diagnosis not corrected by postmortem examination must be added the impossibility of surveying the histories of several generations in a given family. This is due to the fact that, in the main, cancer affects persons of advanced years and many die before reaching the age of greatest susceptibility, so that it is not possible to gather even meager bits of information that might be handed down from one generation to another. Finally, there is a psychologic handicap to such genetic research, due to the reluctance commonly felt about admitting death from cancer in one's own family.

To overcome these various obstacles special methods of statistical investigation had to be devised, of which one of the most skilful is that of Waaler<sup>2</sup>; as seen from his paper, Waaler's inquiry is also outstanding for the quantity and quality of the source material. The foundation for the study was the register of the Norwegian Cancer Committee, consisting of data collected over twenty-one years and covering the records of 6,000 patients from all parts of the country. The existence of cancer in families during three generations had to be determined, with special emphasis on its existence among the brothers and sisters of the patients. For control material, Waaler used all the data relating to spouses of patients. These data had the additional value of providing evidence on the influence of purely environmental conditions, including the possibility of infection for persons living under the same roof.

The questionnaire method proved wholly inadequate for gathering the precise information needed in such research. A corps of one hundred and fifteen medically trained helpers was distributed throughout the country, and the work went on for many months, till the mass of data required for this complicated statistical analysis was assembled. The results, published in 1931, cannot be summarized briefly, but some of the more generally applicable findings may be indicated by the following quotation from a paper by Weller<sup>3</sup>:

As to spouses, he [Waaler] found that no excess cancer mortality over the general population exists. The incidence of cancer was significantly greater among the sisters of cancer patients than among the wives of the patients or in the general population. Among male figures show that the proportional cancer mortality in the siblings varies with cancer incidence in the parental generation. When one or the other parent had cancer, the proportions for male and female sibs were 407 and

1. Cramer, W.: The Importance of Statistical Investigations in the Campaign Against Cancer, *Am. J. Cancer* 29:1-19, 1937.

2. Waaler, G. H. M.: Ueber die Erbllichkeit des Krebses. *Skrifter utgitt av det Norske Videnskaps-Akademi i Oslo: I. Mat.-Naturv. Klasse*, 1931, no. 2.

3. Weller, C. V.: Intrinsic Factors in the Etiology of Neoplasms, *Am. J. Cancer* 30:39-46, 1937.

53.8 per cent. When both parents died at ages over sixty years, of disease other than cancer, the corresponding figures were 21.7 and 23.1 per cent. The female sibs of patients with cancer of the breast, uterus, or ovaries showed a larger proportion of cancer than the male sibs, and the type of tumor from which the patient suffered was largely represented in her female sibs. For instance, cancer of the breast appeared in 44.7 per cent of the cancerous sibs of patients with cancer of the breast, and in but 16.5 per cent of the cancerous sibs of females with cancer other than of the breast. However, no such relationship was found to exist when the siblings of males with cancer of the lip were considered.

In an extensive review of Waaler's paper, Greenwood<sup>4</sup> pointed out:

Waaler's findings are consistent with, although they do not prove (as Waaler rightly says), the truth of an hypothesis of the following type:

(1) That some forms of cancer (e. g. lip cancer) are produced quite independently of any inheritable anlagen, and that extrinsic factors have greater, perhaps exclusive influence upon males.

(2) Second, that the heritable factors are two independent factors, both of which occur with a frequency of about 16 per cent.

Wassink<sup>5</sup> made a similarly thorough investigation in the Netherlands, obtaining results greatly like those of Waaler. One of the most important observations in both studies was the striking difference in behavior of tumors of different localization.

The existence of a pronounced hereditary tendency to mammary cancer has also been demonstrated by the Russian investigator Martynova,<sup>6</sup> who, in an elaborate study of 201 family histories, found that cancer of the breast is not only more frequent in all female relatives of patients suffering from mammary cancer but eighteen times as frequent in the mothers of patients with cancer of the breast as in mothers of similar age among the control population.

The complexity of the problem can be easily realized from these quotations, although they convey but a weak impression of the vast extent of the labors of investigators in this field. One of the most significant conclusions emerging from these admirable studies is that cancer is not a unit disease, because tumor growths of different sites and types behave genetically in different ways.

This fact emphasizes clearly the necessity for recording and investigating data on the incidence of cancer in man separately for each tissue and organ.

## II. FAMILIES WITH CANCER

From time to time in medical literature families are described who show not only an extremely high incidence of cancer among their members but a similar and sometimes unusually early onset of the disease and localization in the same or homologous organs. One well known and much cited pedigree, that of "family G.," was first reported by Warthin<sup>7</sup> in 1913, who presented a further study twelve years later.<sup>8</sup> In 1936, Hauser and Weller<sup>9</sup> brought the record of Warthin's "cancer family" up to date and gave the following figures with regard to the incidence and the site of tumors in this history: Up to 1936 there have been observed "43 primary carcinomas in 41 individuals from a total population of 305. Since only 174 have attained the age of twenty-five years, this gives the high cancer incidence of not less than 23.6 per cent in those reaching that age.

But Hauser and Weller rightly found the anatomic location of the primary lesions even more significant than the high incidence of cancer in this family, with 26 of the 43 carcinomas having occurred in the gastrointestinal tract and 15 in the endometrium. Of the carcinomas, 20 occurred in males, all of them in the gastrointestinal tract. Since not a single example of cancer in other organs occurred among these persons, pure chance cannot account for this unique distribution.

Interest in the study of such family histories far antedates the modern science of genetics. Long before the discovery of Mendel's laws, the attention of laymen and physicians was drawn to the occasional high incidence of cancer, especially when it concerned a famous family, like that of Napoleon Bonaparte, who died of cancer of the stomach, while three sisters, one brother, his father and his grandfather are all supposed to have died from gastric carcinoma. The pedigree, as published recently by Sokoloff,<sup>10</sup> may be mentioned because of its historical interest.

In 1856, two famous physicians, Broca and his father-in-law, Lugol, recorded information on a family (probably their own) which included three medical men. Wolff<sup>11</sup> published their

7. Warthin, A. S.: Heredity with Reference to Carcinoma, *Arch. Int. Med.* 12:546-555 (Nov.) 1913.

8. Warthin, A. S.: The Further Study of a Cancer Family, *J. Cancer Research* 9:279-286, 1925.

9. Hauser, I. J., and Weller, C. V.: A Further Report on the Cancer Family of Warthin, *Am. J. Cancer* 27:434-449, 1936.

10. Sokoloff, B.: Predisposition to Cancer in the Bonaparte Family, *Am. J. Surg.* 40:673-678, 1938.

11. Wolff, J.: Die Lehre von der Krebskrankheit, Jena, G. Fischer, 1907, vol. 1, p. 363 (cites report on family by Broca and Lugol in 1856).

4. Waaler,<sup>2</sup> abstracted, *Cancer Rev.* 7:464-470, 1932.

5. Wassink, W. F.: Cancer et hérédité, *Genetica* 17:103-144, 1935.

6. Martynova, R. P.: Studies in the Genetics of Human Neoplasms: Cancer of the Breast, Based upon 201 Family Histories, *Am. J. Cancer* 29:530-540, 1937.

figures in 1907, and again here is evidence of specific organ susceptibility since among the total of 16 cases of cancer 10 were instances of cancer of the breast and 4 of cancer of the liver.

A more recent example, reported in 1932 by Finney,<sup>12</sup> was the family in which 8 members—a mother, 4 daughters and 3 nieces—had all been operated on for cancer at the Mayo Clinic. All but 1 of these patients had cancer of the breast; 3 of the daughters had a second cancer in the other breast, and 1 of these 3 later had cancer of the stomach.

More than a hundred such families have been reported in medical literature. The record most important for this study is that of a type of tumor so rare that the probability of its chance occurrence more than once within the same family is extremely small. For example, Macklin<sup>13</sup> noted that among the 60 cases of retinal angioma (the total recorded up to 1930) 6 cases were in one family and there were two families with 3 cases each.

These and many other pedigrees and observations of the kind leave little doubt as to the importance of hereditarily determined factors in formation of tumors, especially in the localization of certain forms.

### III. THE STUDY OF TWINS

The same conclusions about the hereditary factors in the genesis of cancer follow the now classic method of studies and observations on twins. In 1940, von Verschuier and Kober<sup>14</sup> surveyed the material so far published on the incidence of cancer among twins, giving data for 48 pairs of identical and 61 pairs of fraternal twins in which tumors occurred in 1 or both partners, taking into account localization of the disease in each case. Because the authors were dissatisfied with the way in which the material had been assembled, expressing the opinion that it could not yield conclusive statistical evidence on analysis, since it was made up largely of selected cases or series of cases, they added a preliminary report on their own unselected series of 23 pairs of identical and 56 pairs of fraternal twins.

From their analysis of this extended series (188 pairs in all) von Verschuier and Kober

decided that so far there was no proof of the existence of a general hereditary predisposition to cancer, although they confirmed earlier findings of definite hereditary factors with respect to the localization of the disease.

Similar conclusions had been reached by Kranz in 1932<sup>15</sup> from his analysis of 22 cases and by Versluys in 1934<sup>16</sup> from his 27 cases of tumor in twins.

The factor for localization is especially prominent in cases of cancer of the stomach, in which, as von Verschuier and Kober pointed out, the behavior of the disease differs in identical and nonidentical twins, while no significant differences were observed in the behavior of mammary cancer in identical as compared with fraternal twins.

The number of cases of cancer in twins which has been investigated is still far too small to yield conclusive evidence; indeed, this is only the beginning, and a considerable amount of material must be gathered and studied before statistically valid results can be obtained in this important and promising field of research.

### IV. EXPERIMENTS ON ANIMALS

While the carefully devised methods of human genetics, as used in the study of data on population and family histories or in observations on twins, may help to arrive at some conclusions about the problem of hereditary factors in cancer, they cannot solve it because of difficulties inherent in the nature of the subject matter. To clarify certain fundamental issues experimentation on animals must be employed, whereby it is possible to survey rapidly a number of generations of individuals, watched under controlled conditions and bred appropriately.

Work in this field started with observations on and experiments with spontaneous and transplanted tumors in rodents, especially mice. From among the many workers with whose names this line of research is identified, the following are mentioned, according to the approximate sequence in which their results were presented: Jensen, Borrell, Ehrlich, Apolant, Bashford, Murray, Haaland, Loeb, Cramer, Murphy, Tyzzer, Slye, Little, Strong, Bittner, Lynch and Dobrovolskaja-Zavadskaja.

*A. The Mode of Transmission.*—Four major problems were met by those undertaking a study of the behavior of tumors in animals, and the

12. Finney, W. P.: A Cancer Family, *Proc. Staff Meet., Mayo Clin.* 7:383-384, 1932.

13. Macklin, M. T.: Heredity in Cancer and Its Value as an Aid in Early Diagnosis, *Edinburgh M. J.* 42:49-67, 1935.

14. von Verschuier, O., and Kober, E.: Die Frage der erblichen Disposition zum Krebs, *Ztschr. f. Krebsforsch.* 50:5-14, 1940.

15. Kranz, H.: Tumoren bei Zwillingen, *Ztschr. f. indukt. Abstammungs- u. Vererbungsl.* 62:173-181, 1932.

16. Versluys, J. J.: Zwillingspathologischer Beitrag zur Aetiologie der Tumoren, *Ztschr. f. Krebsforsch.* 41: 239-259, 1934.

literature has centered mainly about the questions of whether there is or is not: (1) a species difference in susceptibility or refractoriness to formation of tumor; (2) an inheritable general predisposition or refractoriness to formation of tumor; (3) an inheritable proneness to specific types of tumor or to specific localization of the disease. And if these queries are to be answered in the affirmative, there remains a fourth question: What is the mode of transmission of the hereditary traits involved, expressed in mendelian terms?

Various methods have been developed by different investigators, according to their ideas of how these questions might best be answered. The amount of work accomplished in this line is enormous, defying a short survey. But in spite of widely different opinions about the proper procedure, certain highly important observations have been verified and finally established as facts by the brilliant and tireless work of many investigators, and there is now general agreement on the answers to the first three questions:

1. Species difference: Cancer is a disease affecting all species of vertebrates, but different species behave differently in general susceptibility to formation of tumor as well as in predisposition to specific types of tumor and to specific localization.

2. General predisposition: There is likewise an undoubtedly different behavior in general susceptibility or refractoriness to formation of tumor among mice of genetically different strains.

3. Localization: Further, there are inheritable factors for specific types and specific localization of tumors. Such genetically determined differences are especially distinct in susceptibility or refractoriness to mammary cancer in mice, which is the most thoroughly investigated form of the disease.

Cancer of the breast, for example, has been found to occur spontaneously in a large percentage and can be developed by appropriate breeding methods in over 90 per cent of the mice of certain strains, known as high cancer strains, while in other strains it hardly occurs at all and cannot be induced artificially, so that the figure for mammary cancer remains practically zero in the low cancer strains.

By appropriate crossing of high and low cancer strains, the percentage of mammary cancer in the progeny can be varied almost at will.

4. Mendelian mechanism: Although these important basic facts have been established to the general satisfaction of the investigators, there is still much divergence of opinion as to the men-

delian mechanism that is involved in the transmission of the traits.

The question as to whether susceptibility and refractoriness to formation of tumors are dependent on multiple factors or whether they are unit characters and, furthermore, whether they are dominant or recessive has precipitated a long controversy in genetic literature; the discussion has been heated at times.

One of the prominent workers in the field, Slye,<sup>17</sup> after many years of observation on the genetic behavior of cancer of the breast in mice, involving many generations and many thousands of individual records and autopsies, arrived at two conclusions: First, the genetic difference between susceptibility and insusceptibility to cancer involves one gene; that is, they are unit characters; second, in the stock of her laboratory, susceptibility to cancer behaves like a recessive; while insusceptibility behaves like a dominant character.

Little<sup>18</sup> and other investigators have, with apparently good reason, contradicted Slye's conclusions. In the course of the discussion, Bernstein compared her findings with the protocols of the experiments performed by Loeb and Lathrop, and in his statistical analysis he was able to reconcile seemingly contradictory observations in the two investigations, purely on the basis of statistical reasons.

Bernstein<sup>19</sup> finally reported in 1930 that he was inclined to assume that Slye's viewpoint was correct as to the recessive character of susceptibility to mammary cancer in mice.

But with much evidence amassed in the years immediately following Bernstein's analysis, it now appears obvious that the mode by which mammary cancer is transmitted is not nearly so simple as that.

*B. Extrachromosomal Factors and the Milk Factor.*—Even yet it remains to be determined whether transmission follows strictly mendelian laws, since recent observations by Little and other members of the staff of the Roscoe B. Jackson Memorial Laboratory<sup>20</sup> and indepen-

17. Slye, M.: Studies in the Incidence and Inheritability of Spontaneous Tumors in Mice (a series of reports, the first of which appeared in *Ztschr. f. Krebsforsch.* 13:500-504, 1913, and the next in *J. M. Research* 30:281-298, 1914, where the series was continued for some years, after which it was continued in the *Journal of Cancer Research*).

18. Little, C. C.: Evidence that Cancer Is Not a Simple Mendelian Recessive, *J. Cancer Research* 12: 30-46, 1928.

19. Bernstein, F.: Ueber die Erbllichkeit und Natur des Krebses, *Med. Klin.* 26:1583-1587 and 1621-1625, 1930.

20. Little, C. C.: The Existence of Non-Chromosomal Influence in the Incidence of Mammary Tumors in Mice, *Science* 78:465-466, 1933.



dently by Korteweg<sup>21</sup> in Amsterdam have demonstrated that development of cancer of the breast in mice may depend largely on cytoplasmic or extrachromosomal factors.

In addition, it was shown by Little and Bittner<sup>22</sup> and subsequently confirmed by other investigators that the influences of foster nursing, the so-called milk factor, are also operative. Mice nursed by mothers of a high cancer strain show a significantly higher incidence of mammary cancer than litters nursed by mothers of a low cancer strain, and vice versa; while nursing has little or no bearing on the development of primary pulmonary carcinoma.

These are obviously most important findings, the implications of which in the development of cancer are now under thorough investigation.

However, with these questions still unsettled, even in experimentation on animals, it is obviously too early to try to make definite statements about the mode of transmission that may be involved, that is, whether through unit characters, dominant or recessive, or through cytoplasmic influences or to try to relate these findings, translated into mendelian terms, to the far more difficult problem of cancer in a human being.

But, one may ask, what practical value results from such genetical work with animals? Can it show anything tangible, increasing understanding of human cancer?

The answer is that work in animal genetics has shown with some approximation to certainty that heredity does play a part in certain forms of the disease and further that the hereditary factors are not of equal significance and that they differ according to the type and site of the tumor. These facts mean that cancer cannot be regarded as an entity in its genetic aspects, a definite if negative conclusion, which will be useful in guiding further inquiry. Again, it has been learned, in part through experimentation on animals, that hereditary factors must not be given undue weight or regarded as the sole conditioning elements in growth of cancer but that other influences have a part.

#### V. CANCEROGENIC AGENTS

By a fortunate coincidence, just about the time knowledge in the genetic field of cancer research

had been enormously widened, important developments in apparently unrelated fields made possible an increasingly successful study on the relation between external and constitutional factors in the growth of tumors. About thirty years ago several independent investigators found that cancer could be induced in the tissues of animals by application of various agents, including certain parasites, viruses and chemical compounds.

*A. Parasites.*—In 1913, Fibiger in Copenhagen<sup>23</sup> stated that cancer of the forestomach of the rat could be induced by infection with the parasite *Gongylonema neoplasticum*.

*B. Virus.*—Rous<sup>24</sup> in 1911 first described a transplantable sarcoma in a chicken, produced by the injection of a cell-free extract, supposedly a virus, into a normal fowl; after this much work with viruses was done, by Rous, Gye and others. The observations of Fibiger and Rous offer many important leads in search for a possible prime causative agent in formation of cancer. But it has not yet been demonstrated convincingly that either a parasite<sup>25</sup> or a virus is such a prime agent, whether in rodents or in man, while in both organisms cancer may be produced more readily by the different means of chemical compounds.

*C. Chemical Compounds.*—It has long been observed that some substances in soot and tar must have cancerogenic properties; so-called occupational cancers, such as "chimney sweep" cancer and cancer of the skin among workers coming in contact with tar, especially that originating from gas works, were well known and often described in medical literature of the last century.

The possibility of inducing cancer by chemical means was first demonstrated in 1915 by two Japanese workers, Yamagawa and Ichikawa,<sup>26</sup> who found that they could do this by continuously painting the skin on rabbits with tar, whereas Tsutsui<sup>26b</sup> in 1918 succeeded in obtain-

23. Fibiger, J.: Untersuchung über eine Nematode (*Spiroptera* sp. n.) und deren Fähigkeit, papillomatöse und carcinomatöse Geschwulstbildungen im Magen der Ratte hervorzurufen, Ztschr. f. Krebsforsch. 13:217-280, 1913.

24. Rous, P.: Sarcoma of the Fowl Transmissible by an Agent Separable from the Tumour Cells, J. Exper. Med. 13:397-411, 1911.

25. Fibiger's work on the rat is now, in view of the research work of Passey, Bullock and Rhodenburg, Cramer and others, considered of doubtful value.

26. (a) Yamagawa, K., and Ichikawa, K.: Experimentelle Studie über die Pathogenese der Epithelialgeschwülste, Mitt. a. d. med. Fakult. d. k. Univ. zu Tokyo 15:295-344, 1915-1916. (b) Tsutsui, H.: Ueber das künstlich erzeugte Cancroid bei der Maus, Gann 12:17-21, 1918.

21. Korteweg, R.: Chromosomale invloeden op den groei en extra-chromosomale invloeden op het ontstaan van kanker bij de muis, Nederl. tijdschr. v. geneesk. 79:1482-1490, 1935.

22. Bittner, J. J., and Little, C. C.: The Transmission of Breast and Lung Cancer in Mice, J. Hered. 28:117-121, 1937. Bittner, J. J.: Relation of Nursing to the Extrachromosomal Theory of Breast Cancer in Mice, Am. J. Cancer 35:90-97, 1939.

ing similar results in mice. Shortly thereafter, Bloch and Dreyfuss, in Switzerland, were able to determine that this cancerogenic action was due to neutral, nitrogen-free substances with a high boiling point.<sup>27</sup>

The next most outstanding event occurred when the spectrographic observations of Hieger and Mayneord led a group of British workers to the discovery of a series of pure hydrocarbons with strong cancerogenic properties.<sup>28</sup> A characteristic common to these compounds is a phenanthrene group of benzene rings, similar to the substances known as sterols, which occur in normal metabolism of both plants and animals.

A further striking observation was made when, largely through the work of Doisy and co-workers<sup>29</sup> and of Butenandt,<sup>30</sup> the chemical constitution of the estrogenic substances in the urine of pregnant women was shown to be like that of the most active cancerogenic compound: 1, 2, 5, 6-dibenzanthracene.<sup>31</sup>

The importance of these discoveries, which followed each other in rapid succession, can hardly be overestimated, for with them it was possible to induce tumors in animals by means of chemical agents, the exact chemical structure of which was known and the cancerogenic properties of which could be controlled. Knowledge of these substances enables one to understand how cancer may develop locally, as, for example, in the skin when it is brought into close contact with them for a long enough time. Moreover,

27. Bloch, B., and Dreyfuss, W.: Ueber die experimentelle Erzeugung von Carcinomen mit Lymphdrüsen- und Lungenmetastasen durch Teerbestandteile, *Schweiz. med. Wchnschr.* 2:1033-1037, 1921.

28. Kennaway, E. L.: The Formation of a Cancer Producing Substance from Isoprene (2-Methyl-Butadiene), *J. Path. & Bact.* 27:233-238, 1924. Cook, J. W.; Hieger, I.; Kennaway, E. L., and Mayneord, W. V.: The Production of Cancer by Pure Hydrocarbons: I, *Proc. Roy. Soc., London, s. B* 111:455-484, 1932. Cook, J. W.: The Production of Cancer by Pure Hydrocarbons: II, *ibid.* 111:485-496, 1932. Cook, J. W.; Haslewood, G. A. D.; Hewett, C. L.; Hieger, I.; Kennaway, E. L., and Mayneord, W. V.: Chemical Compounds as Carcinogenic Agents, *Am. J. Cancer* 29:219-259, 1937. Cook, J. W., and Kennaway, E. L.: Chemical Compounds as Carcinogenic Agents, *ibid.* 33:50-97, 1938; 39:381-428 and 521-582, 1940.

29. (a) Doisy, E. A.; Thayer, S., and Veler, C. D.: The Preparation of Crystalline Ovarian Hormone from the Urine of Pregnant Women, *J. Biol. Chem.* 86:499-509, 1930. (b) Veler, C. D.; Thayer, S., and Doisy, E. A.: The Preparation of the Crystalline Follicular Ovarian Hormone: Theelin, *ibid.* 87:357-371, 1930.

30. Butenandt, A.: Ueber "Progynon," ein krystallisiertes weibliches Sexualhormon, *Naturwissenschaften* 17:879, 1929.

31. Domagk, G.: Die synthetisch hergestellten carcinogenen Substanzen und ihre Beziehungen zu physiologischen Produkten, *Ztschr. f. Krebsforsch.* 44:160-186, 1936.

the close chemical relationship between these substances and certain physiologic products of the body gives a clue to the understanding of how, under certain abnormal conditions, a deranged metabolism or the endocrine system may play a part in the development of cancer in organs remote from any external irritation, by providing what Cramer called a favorable "internal cancerogenic environment."

## VI. INTERNAL CANCEROGENIC ENVIRONMENT IN EXPERIMENTAL ANIMALS

*A. Hormones.*—A relation between the endocrine system and some forms of tumor growth has been recognized since 1916, when Loeb and Lathrop<sup>32</sup> made their classic observations on the influence of oophorectomy on the incidence and age at onset of mammary carcinoma in mice. However, while this discovery long antedated those just enumerated in the field of chemistry, the latter have enormously enlarged the understanding of the whole matter.

Investigations by Loeb and his co-workers and Cramer, Andervont, Lacassagne and others have brought to light a mass of facts which definitely shows the importance of the endocrine system and especially of estrogens in the development of mammary cancer. Thus a few years ago, Lacassagne,<sup>33</sup> in his experiments in Paris, was able not only to increase the incidence of mammary cancer in female mice by means of long-continued injections of estrogen but to show that cancer of the breast can be made to develop under the conditions of his experiment in 100 per cent of male mice in which mammary cancer normally did not appear spontaneously.

But here again the most striking differences in reaction could not be explained without the knowledge gained by research in the genetic field. Lacassagne, working with various inbred strains of mice of known genetic susceptibility or refractoriness to cancer, achieved results which varied consistently with the strain, in respect both to the degree to which mammary cancer might be induced by injections of estrogen and to the age at which it was produced. His findings may be summarized from Cramer's report

32. Lathrop, A. E. C., and Loeb, L.: Further Investigations on the Origin of Tumors in Mice: III. On the Part Played by Internal Secretion in the Spontaneous Development of Tumors, *J. Cancer Research* 1:1-19, 1916. Loeb, L.: Further Investigations on the Origin of Tumors in Mice: VI. Internal Secretion as a Factor in the Origin of Tumors, *J. M. Research* 40:477-496, 1919.

33. Lacassagne, A.: Influence d'un facteur familial dans la production, par la folliculine, de cancers mammaires chez la souris mâle, *Compt. rend. Soc. de biol.* 114:427-429, 1933.

on etiology of cancer of the mamma,<sup>34</sup> as follows:

1. Cancer of the breast in inbred strains of mice with a high spontaneous incidence of mammary cancer (72 per cent) could be developed in all male and female mice by treatments with estrogen, with tumors appearing at an early age (4 to 10 months).

2. In a strain with a low percentage (2 per cent) of spontaneous mammary cancer in female mice, mammary cancer appeared after applications of estrogen to both males and females, but only at a late age (9 to 18 months).

3. In a strain in which cancer of the breast did not appear spontaneously in many generations of females, mammary cancer could not be induced in either sex, even if the mice received injections of large quantities of estrogen continuously from birth to maturity.

The bearing which genetically determined factors have on the development and the age at onset of mammary cancer can hardly be demonstrated more convincingly. Lacassagne suggested that the hereditary factor consists of an unequal response of the mamma to the same quantity of hormone. But what is the nature of the hereditary factors which determine such striking differences in the response of the mamma to estrogen?

*B. Endocrine Abnormalities.*—Recent observations may bring nearer an answer to this question. Cramer and Horning<sup>35</sup> have demonstrated that in the RIII strain of mice a high incidence of spontaneous mammary cancer is always associated with a visible pathologic process, known as "brown degeneration," in certain parts of the adrenals, which precedes the onset of mammary cancer. This process seems to be specific for this high cancer strain and has never been seen in the adrenals of mice of the ordinary mixed strain, more than 1,000 of which were examined by the investigators during fifteen years.

Cramer and Horning stated the belief that they have evidence that this pathologic condition may be related to the breakdown of a restraining mechanism which normally antagonizes the carcinogenic action of estrogen on the mamma. A close relation between the action of estrogen, the adrenal glands and the specific susceptibility of

the high cancer RIII strain to estrogenic action seems to be proved by the the following fact:

If mice of the RIII strain in which "brown degeneration" sets in spontaneously are treated with estrogen, the adrenals of these mice undergo a much quicker and more extensive process of "brown degeneration" than the adrenals of mice with a low incidence of cancer.

#### VII. INHERITED LOCALIZATION FACTOR IN MAN

The implication of the findings of Cramer and Horning for the experiments of Lacassagne, and most probably for the whole problem of mammary cancer, is clear. In addition they hint at the possibility that at least the localization factor in certain cases of tumor formation may be explained by abnormal endocrine conditions. These factors may be inherited independently of general susceptibility to formation of tumor, as Bernstein pointed out in the investigations referred to earlier.<sup>19</sup>

*A. Endocrine Traits.*—Bernstein explained that from the protocols of experiments on animals used in his analysis, the problem of whether localization of cancer is determined by factors dependent on general susceptibility was not solved. He expressed the opinion that the factors conditioning localization were not dependent on general susceptibility.

According to Cramer and Horning's observations, a localization factor in mice may be found in an inherited abnormal endocrine trait and most likely in other inborn conditions and the study of these conditions is of the greatest importance to the question of cancer in human beings.

My own investigations, conducted at the Genetics Laboratory of Ohio State University in cooperation with the Columbus Cancer Clinic and the University General Hospital, point in this direction. For example, there is some reason to believe that certain abnormalities in the whole range of the menstrual cycle may give a clue to better understanding of why mammary cancer runs in some families.

A positive relationship between delayed menopause and carcinoma of the breast and of the body of the uterus has already been suggested by some authors. Thus, in 1937 Olch,<sup>36</sup> after investigating the age at menopause among women suffering from mammary cancer, reported his conclusion that the number of patients in this group who continued to menstruate after the age of 50 was nearly five times as high as might be expected.

34. Cramer, W.: On Aetiology of Cancer of the Mamma in the Mouse and in Man, *Am. J. Cancer* 30: 318-331, 1937.

35. Cramer, W., and Horning, E. S.: Adrenal Changes Associated with Oestrin Administration and Mammary Cancer, *J. Path. & Bact.* 44:633-642, 1937. On the Association Between Brown Degeneration of the Adrenals and the Incidence of Mammary Cancer in Inbred Strains of Mice, *Am. J. Cancer* 37:343-354, 1939; Hormonal Relationship Between the Ovary and the Adrenal Gland and Its Significance in the Aetiology of Mammary Cancer, *Lancet* 1:192-197, 1939.

36. Olch, I. Y.: The Menopausal Age in Women with Cancer of the Breast, *Am. J. Cancer* 30:563-571, 1937.

I have checked Olch's figures by comparing them with the recorded ages at menopause among two other groups of women: first, those suffering with cancer of other sites than the breast or genital tissues and, second, patients treated in a general hospital for definitely noncancerous condition. Although, according to the findings of this investigation,<sup>37</sup> the differences between cancerous and noncancerous conditions with respect to age at menopause are not nearly so great as Olch assumes, they are sufficient to deserve more thorough investigation. But in my opinion one must take into consideration not only the age at menopause but the age at onset of menstruation as well, in order to determine the length of time the tissues have been subjected to estrogenic action. This approach would seem the more logical in view of the fact that (in temperate climates at least) the earlier the age at puberty the later the age at menopause; the reverse also holds, that the later the onset the earlier the cessation of menstruation.

Consequently, wide variations in the range of the cycle are bound to occur, so that it covers a relatively long period in the life of some women and a relatively short span in others. With our expanding knowledge of estrogenic action it seems worth while to study these variations more closely, particularly as there seems to be definite support for the belief that the range of the menstrual cycle is hereditarily determined, as suggested by many experienced physicians and by some geneticists.

Aside from the admittedly great influence of environmental factors, there is strong evidence to support the view that at least the time of onset of menstruation is hereditary. Comparing monozygotic and dizygotic twins, Petri<sup>38</sup> found an average difference of only two and eight-tenths months in the time of onset of menstruation in identical twins, but as much as twelve months in fraternal twins. Without going into further details or anticipating the results of my own investigations, it may be said that the assumption is justified that hereditary factors are operative in determining the range of the menstrual cycle.

The question concerned here is whether or not there is an unusually high incidence of cancer of the breast in the female members of families in whom early onset and late ending of the cycle occur or, in other words, in whom unduly prolonged estrogenic activity may create a "favorable cancerogenic internal environment."

37. Blank, F.: Late Menopause and Cancer of the Breast, *Ohio J. Sc.* 44:51-56, 1944.

38. Petri, E.: Untersuchungen zur Erbbedingtheit der Menarche, *Ztschr. f. Morphol. u. Anthropol.* 33: 43-48, 1934.

Cramer, in one of his recent brilliant papers on mammary cancer,<sup>39</sup> remarked that the existence of an inherited internal cancerogenic environment was of the greatest importance for the genesis of mammary cancer in man. And, pointing out that "there are definite indications that this internal carcinogenic environment may be related to endocrine abnormalities," he urged that investigations be made on man in this important matter. Regrettably, his advice has not yet been met with the response it deserves, for here is a wide open field for much needed research.

*B. Inherited Precancerous Conditions.*—Besides endocrine disturbances there are other conditions favoring the development of an internal cancerogenic environment, which further are known in many instances to have a genetic background. For example, von Verschuer and Kober<sup>44</sup> found evidence in their material about twins of a relation between the familial type of achlorhydria and the incidence of gastric cancer, which others noted in a study of family histories.

The true nature of some of the so-called precancerous conditions is not known, though their hereditary character is beyond doubt; for example, neurofibromatosis and tuberous sclerosis, or epiloia, appear as family traits and lead frequently to formation of cancer. Intestinal polyposis has been established, notably through the work of Lockhart-Mummery,<sup>40</sup> Dukes<sup>41</sup> and Jüngling,<sup>42</sup> as a frequent basis for the development of malignant growths in members of families affected by this condition.

Xeroderma pigmentosum offers an example of the role heredity plays in interaction with purely external factors. As is known, this condition, which is transmitted as an incomplete sex-linked recessive, invariably leads to formation of cancer in the skin of all the members of a family who have inherited the disease. There is reason to believe that xeroderma pigmentosum is connected with an inherited abnormality in metabolism, leading to development of photosensitive substances in the body similar to those found in hematoporphyrinuria.

*C. Inherited Metabolic Abnormalities.*—According to Joannovics,<sup>43</sup> it was noted by

39. Cramer, W.: On Aetiology of Cancer of the Mamma in the Mouse and in Man, *Am. J. Cancer* 30: 318-331, 1937.

40. Lockhart-Mummery, J. P.: Cancer and Heredity, *Lancet* 1:427-429, 1925.

41. Dukes, C.: The Hereditary Factor in Polyposis Intestini, or Multiple Adenomata, *Cancer Rev.* 5:241-256, 1930.

42. Jüngling, O.: Polyposis intestini: Hereditäre Verhältnisse und Beziehungen zum Carcinom, *Beitr. z. klin. Chir.* 143:476-483, 1928.

43. Joannovics, G.: Experimentelle Studien zur Geschwulstdisposition, *München. med. Wchnschr.* 63: 575-576, 1916.

Kosanowics that hematoporphyria was present in 14 cases of malignant tumor in regions subjected to the action of sun rays, although it was absent in cases of carcinoma in which the growth was in regions not so subjected. Moreover, Fischer-Wasels<sup>44</sup> stated that the condition in such cases was due to a constitutional anomaly caused by the reaction to light. And, in his paper on the influence of photosensitizing substances, Buengler<sup>45</sup> expressed agreement with Fischer-Wasels that the known hypersensitivity of the skin in xeroderma pigmentosum can therefore be regarded as simply a more severe degree of the same constitutional abnormality.

Roffo<sup>46</sup> observed an increase of cholesterol content in areas of the skin subjected to actinic rays, coinciding with the development of cutaneous cancer. Further research is needed to determine whether this is a reaction normally occurring under the influence of actinic rays or whether it reflects a constitutional tendency to some anomaly in cholesterol metabolism.

#### VIII. RACIAL DIFFERENCES IN INCIDENCE OF CANCER

Differences among various racial groups in the incidence of certain forms of cancer have been reported by a number of observers, notably in connection with the distribution of cancer of the skin and tumors of the stomach and the liver.

*A. Cancer of the Skin.*—Roffo,<sup>47</sup> in further studies of the role of actinic rays in the development of cancer of the skin, pointed out certain differences in reaction which are definitely constitutional or racial. He noted that in general sufferers from epithelioma have white, extremely photosensitive skins, while he has never found a single instance of this condition among Negroes or mulattos or in the native population of such countries as Argentina, though he has examined large numbers of cases.

Findlay,<sup>48</sup> in an important paper on ultraviolet rays and cancer of the skin, made a similar comment eight years before Roffo and cited Hyde's findings in an American study in 1906 to the effect that "the colored races suffer much less

from skin cancer than the whites, among whom cancer of the face, neck and hands is especially common in agricultural laborers." Findlay referred also to the work of Corlett (1915) and McCoy (1920), who considered pigmentation of importance in the genesis of cancer of the skin. In McCoy's series of cases, the distribution of cancer of the face, neck and hands differed according to the type of pigmentation, as follows: 62 per cent in blondes; 31 per cent in *châtains* (those with dark hair but with little cutaneous pigmentation), and 7 per cent among dark-skinned persons.

Findlay further quoted from Molesworth's study in Australia (1927):

"... rodent ulcer and epithelioma both develop in relation to pre-existing keratosis, more especially when the skin is poorly pigmented. Since those of Scottish and Irish descent have as a rule fair skins, the incidence of skin cancer of the face, hands and neck is far greater in these races than among the general population, while among Italians, on the other hand, skin cancer is very rarely seen."

*B. Cancer of Internal Organs.*—Although these conditions undoubtedly point to some genetical influences, it is also evident that environmental factors—such as climate, nutrition, occupation or clothing—are important and may indeed largely account for the differences in site incidence, not alone in cancer of the skin but in that of internal organs.

Clearly, only the most discriminating investigation into all the possible factors, internal and external, can be of value in discovering what are the purely racial influences in the differential incidence of tumor growth in various populations. Such research has already led to important results and the assembly of a vast amount of comparative data from all parts of the world. I can only mention in passing the now classic statistical inquiries of Hoffmann, notably those among the Indians of North and South America and the investigations conducted by Niceforo and Pittard,<sup>49</sup> under the auspices of the Section on Hygiene of the League of Nations. The most fruitful studies of race and cancer are those made in the Far East, with its peculiarly favorable conditions for this kind of inquiry.

In 1935, Bonne<sup>50</sup> reported on certain outstanding differences in the site incidence of cancer as it affected native Malay as compared

44. Fischer-Wasels, B., in Bethe, A.; von Bergmann G.; Embden, G., and Ellinger, A.: *Handbuch der normalen und pathologischen Physiologie*, Berlin, Julius Springer, 1927, vol. 14, pt. 2, p. 1560.

45. Buengler, W.: Ueber den Einfluss photosensibilisierender Substanzen auf die Entstehung von Hautgeschwülsten, *Ztschr. f. Krebsforsch.* 46:130-166, 1937.

46. Roffo, A. H.: *Insorgenza di tumori maligni da irradiazione solare totale*, *Pathologica* 27:443-461, 1935.

47. Roffo, A. H.: Role of Ultraviolet Rays in the Development of Cancer Provoked by the Sun, *Lancet* 1:472-474, 1936.

48. Findlay, G. M.: Ultraviolet Light in Skin Cancer, *Lancet* 2:1070-1073, 1928.

49. Niceforo, A., and Pittard, E.: *Considérations sur les rapports présumés entre le cancer et la race, d'après l'étude de statistiques anthropologiques et médicales de quelques pays d'Europe*, Publ. de la Sec. des Nations: III. Hygiene, Geneva, World Peace Foundation, 1926.

50. Bonne, C.: Cancer in Java and Sumatra, *Am. J. Cancer* 25:811-821, 1935; *Cancer and Human Races*, *ibid.* 30:435-454, 1937.

with Chinese populations in Java which confirmed similar observations made in 1923 by Snijders and Straub<sup>51</sup> about Malay and Chinese laborers in the island of Sumatra.

Bonne found that there is a nearly total absence of gastric cancer among the native Malay population of Java, associated with a similar scarcity of gastric ulcer, though the Chinese in Java and in the tropical parts of the Far East generally have the usual amount of gastric carcinoma and gastric ulcer. It is impossible at present, Bonne explained, to say whether the prevalence or scarcity of gastric carcinoma depends on genetic factors or on external factors of irritation or on both of these. Without raising the question of the nature of the relationship between gastric ulcer and gastric cancer, the peculiar behavior of these two conditions among the native populations of Java and Sumatra suggests that both may be related to a basic factor of etiologic importance. This may prove to be either an inborn racial character or something in the living habits of the Malays, for example their food. All that can now be said, Bonne went on to state, is that rarity of gastric carcinoma appears to be a special characteristic of the nearly 40,000,000 native inhabitants of Java, a fact well worthy of further close study.

Primary liver cell cancer, a form rare in Europe, is of frequent occurrence in the Far East, usually developing in a cirrhotic liver of the Laennec type. This was noted by Bonne in Java and by Snijders and Straub in Sumatra; there are other reports on a similar prevalence of cancer of the liver in certain populations of Africa, including the Bantus and the natives of Cameroon and Nigeria as well as the natives of Northern India. It may not therefore be astonishing to learn that there exists a high frequency of primary liver cell cancer in Japan as well. But, in sharp contrast to the low incidence of gastric ulcer and cancer in the Malays, there is among the Japanese, particularly among males, an extremely high incidence of cancer of the stomach, so that cancer of the liver and of the stomach are together responsible for 75 per cent of the total cancer mortality in Japanese men. In Japanese women cancer of the stomach and liver are less frequent, but still represent 48 per cent of the total cancer mortality.

Cramer, in 1937, referring to these facts in his paper on "The Importance of Statistical Investigations in the Campaign Against Cancer,"<sup>52</sup> pointed to another striking phenomenon in the statistics on cancer of Japan, namely, the excep-

tionally high incidence of cancer of the uterine cervix, which accounts for 32 per cent of cancer mortality among the women, coupled with the extremely low incidence of 3 per cent for mammary cancer. This, Cramer pointed out, is a condition not existing in any other country for which reliable statistics are available; one must agree with his statement that an investigation into the factors possibly responsible for the high incidence of cancer of the cervical portion of the uterus among Japanese women may yield information on the remote causes of cancer in that organ, which may be generally applicable and therefore of great importance.

*C. General Incidence of Cancer.*—Surprisingly, in view of all these racial differences in the incidence of cancer of various sites, international statistics do not reveal any racial differences in susceptibility to cancer in general. On the contrary, there is remarkable uniformity among the races with regard to the total incidence of cancer. Cramer stated that the differences in the frequency with which the various sites are attacked can be accounted for by the varying influence in different races of external conditions, habits and customs.

His view is supported by the findings of Snijders and Straub<sup>51</sup> and of Kouwenaar,<sup>52</sup> who studied the total cancer mortality among the Chinese and Javanese in a certain part of Sumatra. They came to the conclusion that, taking into account the different age distributions, no tangible difference could be observed in the total cancer death rate, as recorded in Western countries.

This interesting fact accords with Cramer's thesis that there seems to be a statistical law operating in such a way that "in a comparison of the cancer mortality of different populations an increase in the incidence in one particular organ due to a direct effect is associated with a diminished incidence in other sites of such an order that the total incidence for the two populations remains the same."<sup>53</sup> Cramer concluded that the coexistence of wide variations in organ incidence with approximately equal total incidence among various countries indicates that the different populations contain about an equal proportion of susceptible persons and that the organ incidence distributes itself over the susceptible moiety.

52. Kouwenaar, W.: Comparative Cancer Statistics in Javanese and Chinese, *Geneesk. tijdschr. v. Nederl.-Indië* 72:392-401, 1932.

53. Cramer, W.: Prevention of Cancer, *Lancet* 1:1-5, 1934.

51. Snijders, E. P., and Straub, M.: Contributions to the Cancer Problem in the Tropics, *Tr. Cong. Far East. A. Trop. Med.* (1923) 5:779-805, 1924.

In other words, there appears to be a general susceptibility to cancer more or less evenly distributed among different populations, with an organ or site distribution determined most probably by an organ-specific or tissue-specific favorable "external" or "internal" cancerogenic environment. Once again the importance is stressed of research into the nature of the disposition to formation of tumors, not only as this may appear to be a general constitutional feature but (and perhaps even more significant) as the disposition is manifested by the formation of tumors in particular sites—that is, the localization factor.

Finally, I suggest that there seems to be possible another line of explanation than Cramer's for the phenomena under discussion: From a genetic point of view the observations just enumerated are highly interesting and call for research into the gene-frequency distribution, which is responsible for general susceptibility to cancer (apparently so stable) and for the factors governing localization of the disease (seemingly so unstable) in different populations.

Appropriate methods for such a study have been devised and are now well developed by the work of R. A. Fisher, J. B. S. Haldane, L. Hogben, L. H. Snyder and C. W. Cotterman in several areas of genetic research. So far as I am aware, no work of the kind has yet been undertaken in the field of cancer, but it is believed that such investigation may yield badly needed information on the general disposition to malignant growths as well as on the localization factors and on the role which heredity plays in both.

#### CONCLUSIONS AND SUMMARY

The complexity of factors noted in regard to the conditions just discussed prevails equally in most forms, types and sites of tumors. And, as the cases of cancer in which direct hereditary transmission can be traced are rare, admittedly they cannot provide a valid answer to the question of whether, or to what extent, inherited susceptibility plays a part in the general incidence of malignant growths. For disorders indicating a purely hereditary proneness to formation of tumor, such as xeroderma pigmentosum or neurofibromatosis, must be differentiated from many other types of tumor formation about which nothing yet is known of an inherited tendency, for example, cancer of the lip, which, according to Waaler, seems to be distributed independently of any inherited disposition.

Much remains to be done before these problems can be solved, but the task will be lighter if the lesson already taught is heeded, that it is

vain to ask "Is cancer hereditary?" but that we must inquire separately for each organ, tissue and type of the disease whether any hereditary factors, direct or indirect, are involved in a specific form of the malady.

A summary of the present position meanwhile shows that enough evidence has been accumulated to warrant at least the following statements:

A. Cancer is not a unit disease, at least so far as its genetic behavior is concerned. Tumors of different sites and types differ in their genetic behavior.

B. Therefore it is unlikely that a heritable condition of "cancer" exists as such. Or, as Haldane<sup>54</sup> has put it: "The genetics of spontaneous cancer is clearly very complicated, and it is quite ludicrous to ascribe it to the activity of one gene, dominant or recessive."

C. There does exist a general inherited disposition, whether of susceptibility or refractoriness, to formation of tumor.

By the term "susceptibility" should be understood the ability of the body to react to specific stimuli with formation of tumor.

By the term "refractoriness" is meant a condition which seems to make the formation of tumors impossible even in the presence of appropriate stimuli.

D. In certain persons, factors exist, most probably inherited independently of a general disposition, which govern the localization of the disease. This localization in turn seems to depend on a favorable "internal environment" in certain tissues or organs.

E. If general susceptibility and inherited favorable internal environment are combined in an individual, these factors may be strong enough in themselves to lead to formation of cancer in certain tissues.

F. If general susceptibility is great in an individual, even relatively slight irritation by agents of many kinds may lead to formation of cancer.

G. But apart from these heritable conditions, there exist purely external cancerogenic agents of various kinds, which are obviously strong enough to lead to formation of cancer in certain tissues, even in persons in whom an inherited predisposition is not distinct or perhaps is too weak to be detected by methods used at present in testing for hereditary traits. Or the predisposition to cancer may not have been inherited but rather acquired under conditions the nature of which is not yet known.

<sup>54</sup> Haldane, J. B. S.: *The Genetics of Cancer*, Nature, London 132:265-267, 1933.

In this survey I have tried to give a picture of the situation of cancer research as seen from the viewpoint of a genetically minded physician. I am only too conscious that many important issues have not been touched on, for example, the mutation theory and the problem of polyploidy and their bearing on the question of development of tumor.

The chief aim of the survey has been to show that the whole problem of heredity and cancer is biologic and highly practical and not one to be dismissed after a somewhat barren discussion of comparative statistics and the mode of transmission. From the outline it will be clear that

I am in agreement with MacDowell<sup>55</sup> (whose work on leukemia in the mouse is a fine example of the best genetic research), when he says:

It is highly regrettable that, outside the immediate circle of geneticists, there seems to be an impression that the gene is self-sufficient and is either dominant or recessive. Especially as applied to neoplasia, this misunderstanding has led to erroneous conclusions both on the part of hostile critics and ardent believers. Dominance is only a special case at the end of a continuous series of interrelations between pairs of genes. No gene can produce its effect without cooperation of many other genes. . . . And, to repeat, genes and extrinsic conditions cooperate in all cases.

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55. MacDowell, E. C.: Genetic Aspects of Mouse Leukemia, *Am. J. Cancer* 26:85-101, 1936.



## PILONIDAL CYSTS

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The large increase in the number of pilonidal cysts coming to our attention for treatment, due to the concentration of military personnel, has stimulated a renewal of interest in this seemingly benign anomaly. Since the prime objective of a medical officer is to return every soldier to active service as soon as possible, the methods of treatment of this condition have entered the field of essential discussion and analysis.

Aside from the apparent increase in pilonidal infections resulting from military concentrations, there appears to be an actual increase in the number of infections in young men of the most vital military age group. Station and general hospitals frequently have special wards for these patients, and the length of hospitalization is an important factor, particularly in time of war. The physical strain and trauma resulting from necessary wartime training have caused many benign pilonidal sinuses to become infected and require treatment that otherwise might have remained dormant during the lifetime of a person leading a more sedentary existence. The men of military age are in the age group in which pilonidal infections are most common, and the direct trauma to the sacrococcygeal region to which men riding on the bouncing, hard seats of jeeps or trucks and paratroopers are subject is responsible for the onset of the infection.

All investigators agree that the anomaly is congenital, but its intriguing nature has resulted in numerous theories of its cause, many of which are fanciful.

In 1867 it was suggested by Warren that the condition was due to a changed polarity in the growth of hairs in the sacrococcygeal region and that the hairs grew inward underneath the skin, instead of growing outward. Later investigators, notably Tourneaux and Hermann<sup>1</sup> in 1887 and Mallory<sup>2</sup> in 1892, concluded that pilonidal sinuses resulted from coccygeal vestiges of the medullary tube. By means of serial sections through human embryos, Mallory was able to

demonstrate histologically the neurogenic residuum left after the spinal cord had been drawn cephalad relative to the downward thrust of the rapidly developing vertebral column. This theory explained the undoubted presence of the coccygeal vestiges, first described by Tourneaux and Hermann, but did not explain the presence of hairs, which are found in about half of a pilonidal cysts and sinuses.

Oehlecker<sup>3</sup> in 1926 also demonstrated vestiges from the medullary canal which formed cysts and sinuses in the sacral region in the fetus but explained formation of pilonidal sinus with the presence of hairs as follows: The coccygeal tip of the curved embryo at the third month of embryonic development is firmly attached to the overlying skin (due to the lack of mesoblastic elements in this region at this stage) and is also connected to the underlying filum terminale of the periosteum of the medullary tube by means of the fibrous caudal ligament. The rapid downward thrust of the caudal tip causes a relative shortening of the caudal ligament and an invagination of the overlying skin, which is unable to keep up with the downgrowth of the coccyx. By the fourth or fifth month of fetal development, the skin which originally covered the tip of the coccyx is drawn upward so as to lie over the third or fourth caudal vertebra, and later it goes even higher. Almost all newborn infants exhibit a postnatal dimple in this region, but the production of a pilonidal sinus depends on the degree of invagination of the skin resulting from the traction, which is further increased by deposition of subcutaneous fat in the surrounding region and development of the nates. With complete invagination, the normal cutaneous appendages and products are also invaginated and rapidly accumulate to form cysts or are discharged intermittently as in fistulas.

However, clinically recognizable symptoms rarely occur before the age of sexual maturity, and this mode of development would result in a caudal direction of the sinus tract.

1. Tourneaux, F., and Hermann, G., cited by Mallory.<sup>2</sup>

2. Mallory, F. B.: Sacro-Coccygeal Dimples, Sinuses, and Cysts, *Am. J. M. Sc.* **103**:263, 1892.

3. Oehlecker, F.: Sacral Abscesses in Congenital Skin Displacements, *Deutsche Ztschr. f. Chir.* **197**:22, 1926.

A new slant on the formation of this congenital anomaly was provided by Stone in 1924 and expanded in 1931,<sup>4</sup> when he compared a sinus found in man with the preen gland which occurs in a great many species of birds. This was the first time that development of the sinus was stated to come from the outside as a normal cutaneous appendage from a downgrowth of special epithelium, unrelated to the vestiges of the medullary canal. Stone expressed the opinion that the coccygeal vestiges can never become so modified as to form skin, even though a cystic remnant should persist into adult life. The preen, or oil, gland serves as a special scent gland concerned with protection and sexual attraction of birds and consists of a number of straight tubules lined by polyhedral cells, which empty into a single small cavity communicating with the cutaneous surface through an epithelium-lined duct. In the mouth of the duct is found a small tuft of hairlike feathers, and the direction of the duct is cephalad, as in pilonidal sinus. Stone remarked that it may be assumed that in certain human beings latent potentiality for the formation of a glandular structure in the sacrococcygeal region analogous to birds, for some reason, develops into an actuality and results in the structure known clinically as pilonidal sinus. Further analogy is suggested by the time of development of pilonidal sinus, during early sexual maturity, both in birds and in human beings.

This line of reasoning was further confirmed in 1935 by Fox,<sup>5</sup> after extensive laboratory investigation with large numbers of pilonidal and embryologic specimens. His conclusions were:

The pilonidal cyst is a congenital lesion due to a process of normal ectodermal invagination in the embryo, which usually disappears but in these cases has persisted in adult life. It commonly contains fine, silky, light colored hair, and mucoid or gelatinous material; is almost always infected, and its walls consist of several layers of epithelial cells with glands and hair follicles. Derived from budding or growth centers in the basal layer of the ectoderm which give rise to hair follicles and glands, it consists of cells which form only hair and glandular appendages. For this reason one never sees teratomata, neurogenic growths, or heterologous tumors in pilonidal sinuses. The lesion becomes evident after the middle of the second decade and is probably associated with the development of secondary sex changes concomitant with puberty.

Gage,<sup>6</sup> in a well documented report, presented evidence to prove that pilonidal sinus results

from an anomalous development of the medullary canal and that the coccygeal dimple results from disturbances in the development of the coccygeal ligament and is not connected with the medullary canal. Thus, he accepted the neurogenic theory of Tourneaux and Hermann and of Mallory for the cause of pilonidal sinus, and he accepted Oehlecker's explanation for the formation of the unrelated coccygeal dimple. Gage cited a series of cases and pathologic specimens illustrative of these conditions. The first case in his series, that of a child with a deep pilonidal dimple which disappeared after section of a fibrous tissue ligament beneath the skin, he cited to confirm Oehlecker's theory of the formation of the dimple by the pull of the caudal ligament. Successive cases were cited to illustrate increasing amounts of neuroglia tissue with increasing depth of the sinus extension. In 1 case, at reoperation, after a tract was carefully dissected into the sacral canal, the tissue was pulled on and severed with scissors; there was an immediate gush of cerebrospinal fluid into the wound. The entire wound was packed with iodoform gauze and loosely closed with sutures. Histologic examination revealed a sinus tract lined by stratified squamous epithelium, incompletely developed, but there were no cutaneous appendages, hair or sebaceous or sweat glands present. But he did find neuroglia. The patient recovered. The cases of Moise<sup>7</sup> and of Ripley and Thompson<sup>8</sup> were also described to illustrate failure of obliteration of the caudal end of the medullary canal, with persistence of a direct communication between the pilonidal sac and the cerebrospinal canal, complicated by staphylococcic meningitis. Moise proved his case by finding methylthionine chloride (methylene blue) which had been injected into the sinus in the cerebrospinal fluid. Continuous drainage was established by resecting the sinus and performing laminectomy. The patient recovered. In Ripley and Thompson's case pilonidal sinus occurred in a 3½ month old child and was verified at autopsy.

The importance of determining the cause of pilonidal sinus is evident, because the rate of recurrence of pilonidal infection following operative treatment is high and delayed healing is too frequent. Whether this recurrence of infection results from failure to dissect out all the finer

4. Stone, H. B.: The Origin of Pilonidal Sinus, *Ann. Surg.* 94:317, 1931.

5. Fox, S. L.: The Origin of Pilonidal Sinus with an Analysis of Its Comparative Anatomy and Histogenesis, *Surg., Gynec. & Obst.* 60:137, 1935.

6. Gage, M.: Pilonidal Sinus: An Explanation of Its Embryologic Development, *Arch. Surg.* 31:175 (Aug.) 1935.

7. Moise, T. S.: Staphylococcus Meningitis Secondary to Congenital Sacral Sinus, *Surg., Gynec. & Obst.* 42:394, 1926.

8. Ripley, W., and Thompson, D. C.: Pilonidal Sinus as a Route of Infection in a Case of Staphylococcus Meningitis, *Am. J. Dis. Child.* 36:785 (Oct.) 1928.

ramifications of the sinus, with subsequent regeneration, or from persistence of infection or bacterial contamination of the wound in an area which is difficult to keep bacteriologically clean, owing to the proximity of the anus, or from the poor blood supply in this region following formation of fibrous scar tissue or from a combination of these factors, we have succeeded in reducing the rate of recurrence far below that reported hitherto by careful attempts at elimination of all these possible causes.

The diagnosis of pilonidal sinus is made on the basis of the presence of one or more small openings in the midline or close to it over the sacrococcygeal region. Occasionally a tuft of fine, silky hair may be found protruding from the opening, and frequently when infection is present a foul-



A case of pilonidal sinus in which there were seven distinct fistulas.

smelling purulent material may be expressed. A probe may be inserted for varying distances, almost always cephalad, and frequently may go in the direction of a secondary sinus opening on the skin. In 3 of our patients secondary sinus openings were found on the left buttock. One patient presented seven individual and distinct fistulas, each one radiating to the sacrococcygeal region (figure). Each tract was dissected out and closed; healing was by primary union. Rarely, a cyst may be palpable in the sacrococcygeal region, and no pilonidal opening is visible, owing to early overgrowth of epithelium, which converts the pilonidal sinus from a fistula into a cyst. The patients are often hirsute and frequently unaware of the presence of the sinus, unless symptoms are caused by infection, usually following trauma of some kind.

The treatment of choice is surgical removal of the diseased tissue by wide excision, to include all ramifications of the burrowing tracts. Palliative treatment most often does not cure. In order to outline the finer ramifications, many operators have injected various dyes, india ink or paraffin, but Rogers and Hall<sup>9</sup> found this not only unsatisfactory and inaccurate but dangerous and unnecessary. The diseased tissue can usually be recognized by the naked eye, and often the dye stains blood vessels and normal tissue. In 3 instances a stained coccyx was removed, which on section failed to reveal any evidence of pathologic changes in the fascia of the bone. In other cases definite sinus tracts had been only partially filled and stained.

The chief divergence of opinion rests in the method of treatment of the resultant wound, following excision of the cyst. The wound may be left open to granulate and fill in with fibrous tissue; it may be closed primarily; or a combination of the two methods may be used.

Obviously, primary closure should not be employed in the presence of acute infection or when there is question of complete removal of all the diseased tissue. It may also be difficult or unwise to close primarily a wound too widely excised, if dead spaces cannot be obliterated.

At the Oliver General Hospital, except in cases of formation of abscesses, when incision and drainage are performed, frequently with cauterization of the walls of the cyst cavity, the procedure has been excision en bloc, with primary closure of the resulting wound.

Prior to the operation patients with either draining or nondraining sinuses are instructed to take sitz baths several times daily. The sacrococcygeal region is shaved, washed and painted with an antiseptic the day before operation and covered with a sterile towel. At operation, after careful preparation of the area, as little healthy tissue is removed as is consistent with complete excision of the sinuses and cyst. The general direction and depth of the tracts are determined by probing, at the onset. The open wound is then irrigated with saline solution of chloroazodin and frequently is dusted with buffered sulfanilamide powder. With careful attention to hemostasis and obliteration of dead spaces, closure is effected by means of nonabsorbable silk or cotton sutures of minimum tension. Undercutting of the skin has rarely been necessary, and the edges of the wound are usually

9. Rogers, H., and Hall, M. G.: Pilonidal Sinus. Surgical Treatment and Pathologic Structure. *Arch. Surg.* 31:742 (Nov.) 1935.

approximated without too great difficulty when the adhesive tape straps, used to expose the pilonidal area and hold the nates apart, are released. A point is made of careful accurate apposition of the cutaneous edges. By means of a grooved director, inserted between two sutures at the lower angle of the wound, any retained blood is gently expressed, and the wound is then covered with either a strip of sulfanilamide film or bismuth tribromphenate gauze, over which is placed a gauze pressure dressing. Wide strips of adhesive tape are used to hold the dressing in place and prevent contamination from the anus. Patients are then instructed to be careful in defecation, that they do not carry infection upward.

Unless definite indications of infection arise, the dressing is unchanged for eight days, after which time a new dressing is applied after inspection and careful drying of the wound. Sutures are removed on the tenth day, and patients are permitted out of bed on the twelfth to the fourteenth day. After one week of ambulation in the ward, with a repetition of sitz baths, the patients are transferred to the reconditioning ward for an average of two weeks, prior to return to duty.

In case of reinfection, the wound is exposed earlier than in eight days, the sutures in the infected area are removed and the infection thereafter is treated daily with chloroazodin in oil packing and buffered sulfanilamide powder.

Generally, stress is placed on extreme cleanliness of the lower part of the back, with frequent shaving in this region and dressings to keep the skin between the nates dry.

In cases of recurrent sinus or persistent infection of an imperfectly healed wound, reoperation is performed exactly as outlined and as often as deemed necessary, after two or three week intervals and after the usual cleansing sitz baths.

#### COMMENT

Half of all the patients in our series fall into the age group of 21 to 25 years and one third into the age group of 26 to 30 years (table 1).

TABLE 1.—Age Incidence

18 to 20 years.....	14%
21 to 25 years.....	49%
26 to 30 years.....	29%
31 years or over.....	8%

Eleven per cent of the patients required repeated excision of the pilonidal area, when draining sinuses recurred. Twenty-four per cent of the patients in whom the wound failed to heal by primary union because of a breakdown in a portion of it were nevertheless discharged for

duty in about fifty-one days following operation, having been cured by means of conservative treatment. We have found that healing is more rapid with primary than with secondary closure because of partial closure of the wound.

Table 2 summarizes the results of the first 100 patients treated at the Oliver General Hospital.

TABLE 2.—Results of Excision

Healed by primary union.....	63%
Healed by secondary union after primary closure....	24%
Recurrences .....	11%
Average stay in the hospital, including 2 weeks of reconditioning .....	51.7 days

Occasionally patients have been returned from the reconditioning ward, where they had been transferred as cured, prior to return to duty, because of reinfection, which became apparent with marked increase in physical activity. This fact led us to speculate about the effects of full military activity on apparently healed sinuses. Reports<sup>10</sup> have appeared in the literature in which healing by primary union has been almost 100 per cent, without any follow-up information. Accordingly, a simple questionnaire was sent to the commanding officers of the patients returned to duty, requiring only a check to indicate whether the patient was performing full duty or whether it was necessary that he be rehospitalized (table 3). It was found that 57 patients

TABLE 3.—Replies to Questionnaire

Returned to full duty.....	57%
Rehospitalized for recurrence of infection.....	2%
No replies received.....	25%
Lack of information about patient.....	6%

were performing duty, 2 were rehospitalized and 6 were unidentified. Replies were not received concerning the remaining 35, many of whom, however, we have reason to believe are overseas performing full duty. Thus we may conservatively estimate, from the number of definite answers received, that recurrences developed in not more than 5 per cent of the patients discharged from the hospital.

It is interesting to note that only 2 patients of the 54 who were admitted to the hospital without previous operation had recurrences; 1 of these was just being returned to duty at the time of writing after four operations, the last of which was performed by the open treatment method.

10. Camp, M. N., and Polites, N.: Symptomatic Pilonidal Cyst Operative Treatment, *Am. J. Surg.* 59: 541, 1943.

Rogers and Hall,<sup>9</sup> in their series of 181 cases, reported that with primary closure the rate of recurrence in civilian patients who had never been operated on before was 31 per cent and in patients who had had a previous operation it was 100 per cent. Other writers have reported even larger percentages of recurrence with the primary suture method. An all-inclusive questionnaire of the members of the American Proctologic Society gave a rate of recurrence of 23.29 per cent with the primary suture method and a rate of only 1.13 per cent with the open method.

In our opinion the problem of pilonidal cysts and their delayed healing is one of infection rather than true recurrence of pilonidal sinuses. We have seen numerous instances of reinfection after reasonably certain surgical removal of all the pilonidal sinus and infected tissue. The "recurrent sinuses" differ from the true pilonidal sinus in that hairs are not found in the former, whereas one would reasonably expect to find hairs in about 40 per cent of the true recurrent sinuses. Primary closure shortens the stay in the hospital, often by many months, and in order to decrease chances for infection we have used various antiseptics before and after closure of the wound. The use of fine nonabsorbable sutures, with gentle approximation of the walls of the wound and cutaneous edges, has also aided in minimizing the chances for infection and in improving heal-

ing of the wound. We have used chloroazo solution, buffered sulfanilamide powder and muth tribromphenate gauze to cover the cision. Despite these measures, reinfection occurred. We are now planning to study a comparable series of cases in which penicillin will be used, both locally and generally, and in which the same careful surgical technic and postoperative care will remain unchanged.

#### SUMMARY

Follow-up inquiries about the first 100 patients with pilonidal cysts treated at the Oliver General Hospital indicate that about five per cent have been rehospitalized after discharge from the hospital.

The average stay in the hospital was fifty-one and seven tenths days following operation.

Good results are obtained by careful attention to surgical principles in the handling of tissue and to antibacteriologic details in postoperative care.

Successful treatment of pilonidal sinus, in our opinion, is primarily a problem of wound healing regardless of the exact method of surgical removal. The ideal agent for combating bacterial contamination has not yet been found, nor are all the factors influencing the healing of granulating wounds fully understood.

# RUPTURE OF INTESTINE CAUSED BY NONPENETRATING TRAUMA OF THE ABDOMINAL WALL

A REPORT OF CASES

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It has been recognized for hundreds of years that nonpenetrating trauma of the abdominal wall may cause intestinal perforation. The trauma need not be particularly severe, and frequently it causes no gross lesion of the abdominal wall itself. In view of the tremendous number of adequate injuries sustained every day by any large group of workers, the conclusion is inescapable that a special combination of circumstances must be present to cause actual perforation. Presumably the loop of intestine must be filled with either fluid or gas and must be fixed against an unyielding portion of the posterior abdominal wall, so that it cannot slip out of the way of the traumatizing force; this in turn implies a force acting in just the right direction.

The importance of this uncommon lesion lies in the disparity between the apparent triviality of the blow and the serious consequences of a failure in diagnosis. One must always keep in mind the possibility that a seemingly minor abdominal blow may have caused actual perforation of the intestine. Such perforation may of course also result from more serious trauma, such as may be caused by an automobile accident, in which intestinal perforation is accompanied by other gross injuries; this paper, however, is principally concerned with the results of relatively minor trauma.

Early diagnosis is essential for proper treatment. In a group of 17 cases reported by Poer and Woliver<sup>1</sup> diagnosis and treatment were delayed more than twelve hours after the accident; in this group the mortality was 70 per cent. In 14 cases of their series, diagnosis was made

early and prompt treatment was instituted, with a mortality of "only 35 per cent."

In cases of intestinal perforation accompanied by other severe injuries, the intra-abdominal lesion may easily be overlooked on preliminary examination; signs and symptoms of acute peritonitis, developing a few hours later, should immediately be recognized by the surgeon as a possible indication of intestinal perforation. With the type of injury considered in this paper, there is likely to be an interval of several hours during which abdominal symptoms are minimal and signs are confusing. The intestinal wall is sensitive only to distention, so that the perforation as such causes no symptoms; the symptoms are those of peritonitis, which will develop with greater or less speed, depending on a variety of factors, such as the site of perforation, the composition of the leaking intestinal contents and the amount of leakage.

Poer and Woliver<sup>1</sup> gave three mechanical explanations for the delayed appearance of symptoms:

1. Incomplete rupture: In many instances severe bruising of the intestinal wall occurs which sloughs through several hours or even days later because of the development of local necrosis. Spillage is facilitated by the onset of peristalsis after the intake of food or fluids.

2. The production of intestinal paresis by the injury, which inhibits peristalsis for a sufficient time to allow an exudate of plastic lymph to seal the opening. After the patient has recovered from primary shock or after the intake of food, peristaltic action is resumed, with consequent leakage. Cope<sup>2</sup> first described this interesting theory in 1914.

3. Prevention of leakage: Leakage may be prevented mechanically by the plugging of the opening by the mucosal layers or, in the case of complete transverse division, by contraction of the circular musculature of the divided ends.

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1. Poer, D. H., and Woliver, E.: Intestinal and Mesenteric Injury Due to Nonpenetrating Abdominal Trauma, *J. A. M. A.* 118:11 (Jan. 3) 1942.

2. Cope, V. Z.: The Early Diagnosis and Treatment of Rupture of Intestine, *Proc. Roy. Soc. Med. (Surg. Sect.)* 7:86, 1914.

Shock is generally not an outstanding feature in these cases. Some pain is usually present from the beginning; Counseller and McCormack<sup>3</sup> stated that the pain is usually constant, dull and aching, not colicky. They expressed the opinion that continued vomiting after recovery from shock is a valuable early symptom and rigidity is the most valuable single sign. Cope<sup>2</sup> stressed the importance of rectal tenderness, due to the gravitation of irritating intestinal contents into the pelvis. There is seldom enough free gas in the peritoneal cavity to obliterate hepatic dulness, but roentgen examination (made with the patient standing or lying on his side, with the x-ray beam directed horizontally) may be of value. Cope<sup>2</sup> stated that he would submit a patient to laparotomy if in the absence of thoracic and renal injury the following signs and symptoms were present: (1) severe abdominal pain persisting for six hours accompanied by vomiting, a gradually rising pulse rate, local rigidity and deep local tenderness or (2) absent or slight abdominal pain with a steadily rising pulse rate, especially if the patient is restless and listless.

In short, the two important points are: first, to keep in mind the possibility of intestinal perforation following even minor trauma to the abdominal wall and, second, to explore the abdomen promptly at the first sign of peritonitis. It is better to explore a few normal abdomens and maintain a mortality rate of 1 per cent or less than to miss one perforated intestine and deny the patient his only real chance of recovery.

The operative procedure is standard. Most of the perforations occur in the jejunum or ileum, and the incision should be planned to permit thorough exploration of the whole small intestine. Counseller and McCormack<sup>3</sup> advised examination of the bowel from one fixed point to another, a few inches at a time. If a perforation is found, it should be covered with a warm moist sponge and exploration continued. The reason for this is that multiple perforations may be present so close together that resection is advisable. If this should be the case, time would have been lost closing the first perforation.

The following cases were observed by us at the United States Marine Hospital, San Francisco, and are reported with the permission of Dr. S. L. Christian, medical officer in charge. The first 4 cases are instances of the uncomplicated type of injury, in which there was no trauma of the abdominal wall. The mortality rate, 25 per cent, in these 4 cases is comparable to the mortality rate of 35 per cent reported by

Poer and Woliver.<sup>1</sup> The 1 patient with no injury of the abdominal wall who died was an elderly Negro with arteriosclerosis, whose usual blood pressure may have been higher than that recorded after his admission to the hospital. The coroner's autopsy failed to discover the reason for the suddenness of his death; he must presumably be considered the victim of surgical shock.

Cases 5 and 6 are illustrative of complicated intestinal rupture. In case 5 rupture of the jejunum by nonpenetrating trauma was accompanied by other severe injuries, which masked the abdominal symptoms and which made us believe that exploratory operation was contraindicated after abdominal symptoms did appear. The patient died in sudden shock thirty-five hours after admission to the hospital. In case 6 there was a wound of the abdominal wall with extrusion of viscera and intestinal rupture; the appearance of the intestine suggested a bursting type of rupture similar in mechanism to that in the other cases reported, rather than a direct laceration of the intestine by the traumatizing force.

The mortality rate is recapitulated as follows:

In 4 cases of uncomplicated rupture of the intestine by nonpenetrating abdominal trauma, the mortality rate was 25 per cent; in 1 case of rupture by nonpenetrating trauma complicated by other serious injuries, the mortality rate was 100 per cent; in all 5 cases of rupture by nonpenetrating trauma, the mortality rate was 40 per cent; in 1 case of rupture of the intestine accompanied or caused by penetrating trauma, the mortality rate was 0; the mortality rate in all 6 cases was 33.33 per cent.

#### REPORT OF CASES

##### CASES OF UNCOMPLICATED RUPTURE

CASE 1 (Hunt).—R. H., a white merchant seaman 56 years old, was admitted to the hospital at 10:49 p. m. on Nov. 28, 1940.

*History.*—The patient was injured about 3 p. m. on November 28 while at work on shipboard. He was struck in the right lower portion of the abdomen by the end of a wooden plank. The blow was apparently not severe; he had no pain at the site of injury but noticed a desire to urinate. After voiding clear yellow urine he experienced priapism lasting about one-half hour, accompanied by extreme tenderness of the testicles. He continued working until 4:30 p. m., then went home and had a drink of whisky and beer. He slept for about one hour and then awoke with severe sharp pains throughout the abdomen; in his words, he had a "hot, throbbing sensation in the stomach." He was nauseated but did not vomit. He was taken to the San Francisco Hospital by ambulance, given a hypodermic injection and then transferred by ambulance to the United States Marine Hospital. His family and personal history were noncontributory except for the fact that a left inguinal hernia had been present since 1933. This had always been reducible.

3. Counseller, V. S., and McCormack, C. J.: Subcutaneous Perforation of the Jejunum, *Ann. Surg.* 102: 365 (Sept.) 1935.

**Examination.**—His temperature was 37 C. (98.6 F.), his pulse rate 90 and his blood pressure 140 systolic and 70 diastolic.

**Abnormal Findings:** The heart was somewhat enlarged, with a mitral systolic murmur. The abdomen was rigid, with generalized tenderness, which was direct and rebound and maximum in the lower portion of the abdomen. There was no ecchymosis or abrasion of the abdominal wall. A reducible indirect inguinal hernia was present on the left side. Small bilateral hydroceles were observed in the tunica vaginalis of the testis.

**Course.**—A tentative diagnosis of ruptured intestine was made, and immediate operation was decided on after consultation with Dr. Robert A. Jones, chief surgeon. The operation was started at 1:42 a. m., on November 29, with the patient under spinal anesthesia induced with 150 mg. of metycaine hydrochloride. The peritoneal cavity was opened through a lower midline incision. It contained at least a liter of greenish intestinal contents, resembling thin pea soup. On the antimesenteric border of the small intestine in the proximal third of the ileum there was a perforation about 8 or 9 mm. in diameter. The loop of intestine containing the perforation lay in the left lower quadrant of the abdomen. The terminal portion of the ileum seemed somewhat thickened and rather doughy, but there was no gross abnormality of the intestine in the region of the perforation. No enlarged mesenteric glands were seen, but careful search for them was not carried out. The spilled intestinal contents were sucked out as completely as possible. The perforation was closed transversely with a continuous through and through suture and interrupted Lembert sutures of fine chromic surgical gut. The peritoneum and the posterior sheath were closed with continuous no. 0 chromic surgical gut sutures. The anterior sheath was closed with interrupted "near and far" sutures of no. 0 chromic surgical gut. The skin was closed with interrupted vertical mattress sutures. One small Penrose drain was introduced beneath the anterior sheath and a second beneath the skin.

His condition remained good during and following the operation. Wangenstein suction through a Levine tube was instituted immediately after the operation and was continued until December 4, the fifth postoperative day. One cubic centimeter of a 1:4,000 solution of neostigmine methylsulfate was given every four hours for eight days; there was moderate distention for about one week. He had his first bowel movement, with the aid of an enema of saline solution, on December 2, the third postoperative day. Both drains were removed on the same day. His maximum temperature was 38.6 C. (101.5 F.), on the fifth and sixth days. He was discharged from the hospital on Jan. 4, 1941; at that time the wound was well healed, he was eating all and his bowels were moving well.

**CASE 2 (Hunt).**—A. H., a Negro dock seaman 64 years old, was admitted to the hospital at 5:25 p. m. Oct. 9, 1943.

**History.**—The patient was injured about 3 p. m. on October 9, when an empty garbage can toppled from pile, striking him in the lower part of the abdomen. He had moderate abdominal pain; he stopped working and was sent to the hospital. On his arrival, he walked to the hospital, complaining only of slight pain in the lower part of the abdomen.

**Examination.**—His temperature was 37.2 C. (99 F.) taken orally, his pulse rate 70 and his blood pressure 100 systolic and 105 diastolic.

**Abnormal Findings:** The heart was enlarged to the left of the nipple, in the fifth intercostal space. There

was a snapping first heart sound, with a short systolic murmur and frequent extrasystoles. Some generalized abdominal tenderness was noted. There was no abrasion or ecchymosis of the abdominal wall.

**Course.**—On admission to the hospital the patient was examined by the officer of the day and thought to have merely a contusion. Three hours later, at 8:30 p. m., the abdomen was rigid, with acute direct and rebound tenderness across the lower part of the abdomen, and one of us was called. The diagnosis of ruptured intestine was made, and operation was begun at 10:15 p. m. with the patient under spinal anesthesia induced with 140 mg. of metycaine hydrochloride. A transverse incision was made just below the umbilicus, with division of the right rectus muscle. The peritoneal cavity contained several liters of fluid, some of which was clear and straw colored and some of which was bile-stained intestinal contents. There was a perforation 8 or 9 mm. in diameter on the antimesenteric border of the ileum about 50 cm. from the ileocecal junction. There was considerable edema, with punctate subserous ecchymosis of most of the mesentery of the small intestine. The appendix was bound down to the posterior surface of the cecum with old fibrous adhesions, and there was a definite kink in its middle third. There was considerable surface inflammation of the appendix. The peritoneal fluid was removed by suction, and the perforation was closed by suturing the intestine transversely with two rows of continuous sutures and one row of Lembert mattress sutures of no. 5-0 chromic surgical gut. The appendix was removed. The peritoneal cavity and the wound of the abdominal wall were frosted with 8 Gm. of sulfanilamide. The abdominal wall was closed in layers with no. 0 chromic surgical gut sutures plus through and through sutures of silkworm gut, without drainage. A smear of the peritoneal fluid showed staphylococci and streptococci. A culture showed an aerobic and facultative anaerobic hemolytic streptococcus. The patient went into rather severe shock as the perforation was being sutured but responded to ephedrine and left the operating room in fairly good condition. After his return to bed he again went into shock but improved after an infusion of plasma and 10 per cent dextrose solution. A Levine tube was passed into his stomach, and continuous Wangenstein suction was started. At 2 a. m. on October 10, his blood pressure was 210 systolic and 96 diastolic and his pulse rate was 64 and of good quality. At 5 a. m. he pulled out the Levine tube; this was reinserted. At 5:30 a. m. he was cold and clammy but sleeping quietly. His pulse rate was 78, his blood pressure 162 systolic and 84 diastolic and his respiratory rate 20. At 9:10 a. m. his temperature was 37.2 C. (99 F.) taken orally, his pulse rate 92, his respiratory rate 20 and his blood pressure 110 systolic and 84 diastolic. He was restless, cold and clammy. He was given 250 cc. of plasma and 1,000 cc. of 10 per cent dextrose solution intravenously and 4 cat units of digalen intramuscularly, with some improvement. At 3 p. m. his blood pressure was 110 systolic and 80 diastolic. He died suddenly at 4:55 p. m.

**Autopsy.**—Postmortem examination was performed by the coroner. There was hypertrophy of the left ventricle of the heart, with marked dilatation of the right side of the heart. There was diffuse sclerosis of the aorta. The coronary vessels were small and sclerotic, and in the left circumflex coronary artery about 1 cm. past the bifurcation there was a heavy sclerotic plaque, opposite which there was a small postmortem thrombus. The abdominal viscera were covered by a fibrinopurulent exudate. No unsutured perforations were found.



CASE 3 (Hunt).—H. S., a white Coast Guard seaman 32 years old, was admitted to the hospital about 6:30 p. m. on Oct. 10, 1943.

*History.*—About three hours before admission he was running to catch a football, while looking back over his shoulder, when he ran into the tailgate of a truck, striking the upper part of the abdomen heavily. He had severe abdominal pain, which could be partially relieved by bending double. He was brought by ambulance several miles to the hospital. There were some nausea and vomiting. At the time of admission he complained of severe midabdominal cramping pain.

*Examination.*—His temperature was 37 C. (98.6 F.) taken orally, his pulse rate 90 and his blood pressure 130 systolic and 85 diastolic.

*Abnormal Findings:* Boardlike abdominal rigidity with direct and rebound tenderness, which was maximum in the umbilical region, was noted. There was no abrasion or ecchymosis of the abdominal wall.

*Course.*—The diagnosis of ruptured intestine was made, and immediate operation was done, with the patient under spinal anesthesia induced with metycaine hydrochloride. A transverse incision was made just below the umbilicus, with division of the left rectus muscle. The peritoneal cavity contained a small amount of brownish fluid as well as bile-stained intestinal contents. The small intestine, the transverse and the descending colon and the bladder were inspected. The only lesion was a perforation 1.5 to 2 cm. in diameter on the antimesenteric border of the jejunum about 15 cm. distal to the ligament of Treitz. The edges of the perforation were everted, and there was a tear of the serosa extending distally from the perforation for about 1 cm. The appendix was bound down to the posterior surface of the cecum with old fibrous adhesions. There was a kink in its middle third and some surface inflammation. The peritoneal fluid was removed by suction, and the perforation was repaired by suturing the wall transversely with two rows of continuous sutures and a third row of interrupted Lembert mattress sutures of no. 5-0 chromic surgical gut. The appendix was removed. The peritoneal cavity and the wound of the abdominal wall were frosted with 4 Gm. of sulfanilamide. The peritoneum and the posterior sheath were closed with continuous no. 0 chromic surgical gut sutures and the anterior sheath and the aponeuroses with interrupted sutures of the same material. The skin was closed with silkworm gut sutures, four of which included a figure-of-eight bite of the anterior sheath. The spinal anesthesia at no time gave complete relaxation and wore off as closure was started. Supplemental anesthesia induced with pentothal sodium and with ether (given by the open drop method) was instituted, but before relaxation could be obtained there was considerable straining, with protrusion of viscera through the wound. These were protected with warm moist sponges, but this incident may have contributed to the later development of a pelvic abscess. A smear and a culture of the peritoneal fluid showed no organisms. A Levine tube was passed into the stomach, and continuous Wangenstein suction was begun. He was given parenteral fluids, and 1 cc. of a 1:4,000 solution of neostigmine methylsulfate was given intramuscularly four times a day for five days and then twice a day for several more days. No distention developed at any time. He had a good bowel movement with the aid of an enema of saline solution on the fourth postoperative day, and the Wangenstein suction was discontinued on the fifth day. Sutures were removed on the tenth day. At this time a stitch-hole abscess near the left angle of the wound was found

and evacuated. Moderate drainage persisted for about six weeks. On the twelfth day mild diarrhea developed and he complained of suprapubic cramping pain. C rectal examination a tender bulging mass anterior to the rectum just above the prostate was found. He was given sulfathiazole by mouth (1 Gm. every four hours) from the twelfth to the twenty-fourth day. The abscess gradually became smaller and finally disappeared. He was discharged from the hospital on December 14, and it was considered that he would be fit for regular duty on Jan. 1, 1944. At the time of discharge the abdominal wound was completely healed, and rectal examination showed no abnormality. His appetite was good, and his bowels were moving normally.

CASE 4 (Bowden).—L. F., a white coastguardsman 18 years of age, was admitted to the hospital on April 9, 1944 at 8:50 p. m.

*History.*—The patient was injured at 6 p. m. on April 9 while riding in a midget speed car at an amusement park. The midget car jumped the track and hit a light post. The car was traveling at a speed of about 10 to 15 miles per hour. In the impact, his abdomen struck the steering post of the car. He had immediate agonizing pain in his abdomen. After a few minutes, however, he got up and walked out of the park onto the street, where he collapsed a few minutes later. He was taken to the emergency hospital and then brought to the United States Marine Hospital, arriving at 8:50 p. m.

*Examination.*—His temperature was 37 C. (98.6 F.), his pulse rate 72 and his blood pressure 120 systolic and 80 diastolic. He was examined by the officer of the day, who found tenderness in the left upper quadrant of the abdomen but no rigidity or rebound tenderness. It was the opinion of the doctor at this time that there was no evidence of intra-abdominal injuries.

*Course.*—When the patient was seen at 8 a. m. on April 10 by the ward surgeon, his temperature was 37.8 C. (100.04 F.) and his pulse rate 120. There were definite tenderness and rigidity in the upper portion of the abdomen, which were more pronounced on the right side. Diagnosis of peritonitis due to intra-abdominal hemorrhage or rupture of a hollow viscus was made. At 10 a. m., with the patient under spinal anesthesia induced with 120 mg. of metycaine hydrochloride which was supplemented by cyclopropane, an upper right rectus incision was made. When the peritoneum was opened a small amount of free fluid was encountered, and there was evidence of a mild general peritoneal reaction. The retroperitoneal space at the level of the duodenum was distended, and there was severe inflammatory reaction of the tissues about the duodenum and head of the pancreas, and the first portion of the duodenum were normal. The peritoneum at the right lateral edge of the upper portion of the second duodenal segment was divided (Kocher's maneuver), and the descending duodenum was exposed by turning it forward, downward and to the left. This brought the posterior surface of the descending duodenum into view. There was a perforation approximately 5 mm. in diameter at this point. This perforation was closed with interrupted sutures of no. 5-0 chromic surgical gut, the stitches being placed transversely. Two reinforcing sutures of silk were used also. The pancreas was examined, and no evidence of injury other than severe distention of the entire large intestine was found. The rest of the intestinal tract was examined, and no abnormality was discovered. A Penrose drain was placed posterior to the duodenum and brought out through a stab wound in the right flank. A few interrupted no. 0 chromic surgical gut sutures

were placed in the peritoneum at the lateral edge of the duodenum. The wound was closed with through and through silkworm gut sutures and the peritoneum with a running suture of no. 0 chromic surgical gut. Continuous Wagensteen suction was begun, and treatment with penicillin, 10,000 units every four hours, was started. The postoperative course was good, and on the sixth postoperative day the highest temperature was 38 C. (100.4 F.) and the pulse rate 90. On this day Wangenstein suction and administration of penicillin were discontinued. He was then allowed to have liquids by mouth, and on the eighth postoperative day he was given a soft diet. The drain had been removed on the fourth postoperative day. The tract continued to drain for approximately two weeks. Cultures taken from the material drained from the tract gave negative results. At the end of two weeks the drainage tract and the abdominal wound had completely healed. His postoperative course was smooth until May 1, when he began to have fever. At the same time he complained of some tenderness over the left femoral vein, and evidence of mild phlebitis was found. The fever gradually subsided, and on May 21 the patient had no complaints and his temperature and pulse were normal. He was taking a liquid diet without difficulty and was up and about the ward.

#### CASES OF RUPTURE COMPLICATED BY OTHER INJURIES

**CASE 5 (Bowden).—**T. M. McG., a white carpenter 46 years old, was admitted to the hospital at 11 a. m. on Nov. 9, 1943.

**History.**—The patient was injured at 10:30 a. m. on November 9 while at work in a ditch about 5 feet (1.5 M.) deep. The sides of the ditch caved in, burying the patient up to his shoulders in large stones and clay. The handle of his shovel was forced against his abdomen by the weight of the surrounding earth. The patient was dug out of the ditch and brought to the hospital immediately. He stated that en route to the hospital he noticed that he was unable to move either leg. Most of the pain at the time of admission to the hospital was located in the lower portion of the abdomen, and there was general abdominal discomfort. His family and personal history were noncontributory.

**Examination.**—His temperature was 36.8 C. (98.2 F.), his pulse rate 100 and his blood pressure 130 systolic and 85 diastolic.

**Abnormal Findings:** There was complete paralysis of the lower extremities, with anesthesia below the level of the iliac crest on both sides. There was moderate abdominal tenderness but no distention or rigidity. There were definite tenderness in the pelvic region and swelling in the right inguinal region. There were an abrasion on the back in the upper lumbar region and some pain on compression of the thoracic cage.

**Course.**—A roentgenogram, taken soon after the patient's admission to the hospital, revealed comminuted fractures of both rami of the pubis on the left side and complete separation of the left sacroiliac joint. There were a fracture through the body of the pubis on the right side, a fracture through the lateral mass of the sacrum and also a fracture involving the posterior inferior and superior spines of the ilium. Soon after hospitalization the patient was catheterized. His urine was clear. In view of paralysis and sensory changes in the lower extremities, the possibility of concussion of the spinal cord was considered. However, in about four hours the patient was able to move his feet and legs, and the anesthesia disappeared from the right lower extremity, but there was still complete anesthesia of the left lower extremity. During most of this time there

was no definite symptom referable to the abdomen. His white blood cell count was 6,000, with 79 per cent neutrophils. The next morning the paralysis of his lower extremities was still less extensive, but hypesthesia persisted over the lower extremities. He was seen at this time by the neurosurgical consultant, who was unable to account for the findings other than to suggest the possibility of vascular embarrassment, secondary to compression of the trunk and abdomen, and advised conservative treatment and further observation. During the morning of the second day, he began to complain of abdominal pain, and examination revealed tenderness over the right side of the abdomen and some rigidity. His condition at that time was not good. His blood pressure was 130 systolic and 90 diastolic, his temperature 36 C. (96.8 F.) and his pulse rate 120. We considered the possibility of general peritonitis, probably on the basis of hemorrhage into the peritoneum. (Because of the severity of the bony injuries and the persistence of hypesthesia and partial paralysis of the lower extremities, exploration of the abdomen was not considered advisable.) At 10 p. m. on November 10 the patient suddenly went into deep shock and despite efforts to revive him died at 10:25 p. m. Autopsy was performed by the coroner, who reported fractures of the pubic bone, separation of the left sacroiliac joint and rupture of the jejunum with peritonitis.

**CASE 6 (Bowden).—**D. W., a 47 year old Negro male laborer, was admitted to the hospital at 4 p. m. on April 11, 1944.

**History.**—At 2:30 p. m. on April 11 the patient was driving a tractor down a steep ramp, when he lost control of the machine. The tractor ran over the edge of the ramp and turned over against a concrete wall, catching the patient in the abdomen between the machine and the wall. There was a knob on the steering wheel of the tractor, and the patient thought that this knob caught him in the right lower portion of the abdomen.

**Examination.**—His temperature was 37.2 C. (99 F.), his pulse rate 100 and his blood pressure 138 systolic and 70 diastolic.

**Abnormal Findings:** The patient's general condition was good. There was an incision in the right lower part of the abdomen, beginning just above the anterior superior spine and running transversely toward the midline. There were several loops of large and small bowel lying on top of the abdomen, and these were covered with spilled intestinal contents.

**Course.**—The patient was taken to the operating room immediately, and, with him under spinal anesthesia induced with 100 mg. of metycaine hydrochloride, the loops of intestine lying on top of the abdominal wall were examined; a perforation approximately 5 mm. in diameter on the antimesenteric border of the ileum about 2 inches (5 cm.) from the ileocecal valve was found. There was little or no evidence of trauma to the intestine surrounding this perforation, and it was our impression that the bowel had been ruptured from the pressure within its lumen, rather than from external trauma. The exposed intestines were then thoroughly irrigated with a large amount of isotonic solution of sodium chloride. The surrounding skin was prepared, and the perforation in the ileum was then repaired with a Connell suture of no. 5-0 chromic surgical gut for the first layer and an interrupted Lambert type of suture for the second layer. The sutures were placed transversely. After the rest of the bowel had been examined, it was returned to the peritoneal cavity. The wound was enlarged to facilitate exploration of the peritoneal cavity. A tear in the posterior part of the peritoneum over the psoas muscle

this state can be maintained by acid-forming diets<sup>7</sup> and by administration of ammonium chloride.<sup>8</sup>

In reinvestigating this problem we decided (1) to limit our observations to the rate of epithelization and (2) to attempt to influence the tissues via the blood, by using such simple substances as ammonium chloride and sodium acetate,

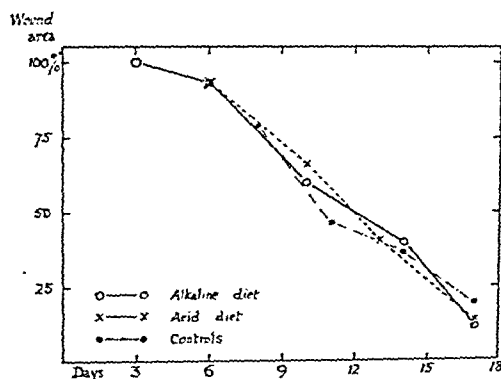


Fig. 1.—Chart showing the average rates of epithelial coverage of experimental wounds in three groups of rats fed acid and alkaline diets.

which are known to produce acidemia and alkalemia if given in sufficient doses, but in our experiments to limit the doses of these salts to "practical" amounts, i. e., by adding them to the drinking water of our animals in sufficient quantity to make a solution of 2 per cent. Greater concentrations than this could not be used satisfactorily in ordinary practice, on account of nausea and vomiting.

#### METHODS

The standard wound was made by the application of a circular loop electrocautery to a shaved and sterilized area below the scapular area of a rat, i. e. in a position where it could not be interfered with by the animal. The circular patch of skin and fascia, 13 mm. in diameter, was removed with scissors from the underlying muscle and trimmed clean, and the edge of the wound was fixed to the muscle by lightly touching it with a small knob cautery. No dressing was used for the wound. Seventy-two hours later measurements were made by tracing the outline on a glass slide with a fine pen, projecting through a photographic enlarger which gave a magnification of  $\times 10$ ; the area was measured with a planimeter. The first area measured was called 100 per cent. Measurements were repeated every few days until healing was nearly complete.

Three groups of animals were used, all of which were fed the usual laboratory standard diet, but with an acidifying or alkalinizing solution (2 per cent) substituted for drinking water. This diet was commenced seven days before the wounds were made. Three groups of rats were observed: (a) Thirteen rats received am-

monium chloride solution; (b) 12 rats received sodium acetate solution, and (c) a control group received water.

Figure 1 shows the results. The three curves represent the average rate of epithelization in each of the three groups and provide data for studying: (a) the effects, if any, of acidification and alkalization on the rate of epithelial growth; (b) some aspects of the mechanism of epithelization.

#### THE EFFECT OF ACIDIFYING AND ALKALINIZING SALTS, ADMINISTERED BY MOUTH, ON EPITHELIZATION

The three curves almost coincide; they show that the rate of epithelization is unaffected by acid and alkaline salts taken by mouth in the doses used by us. Since the salt solutions provided the only fluid imbibed by these animals for twenty-five days, it would appear that, whatever effects these salts might produce under extreme experimental conditions, their effects were practically nil under the conditions of our experiments.

#### SOME ASPECTS OF EPITHELIZATION

Since all three curves practically coincide, we can assume that they represent fairly closely the

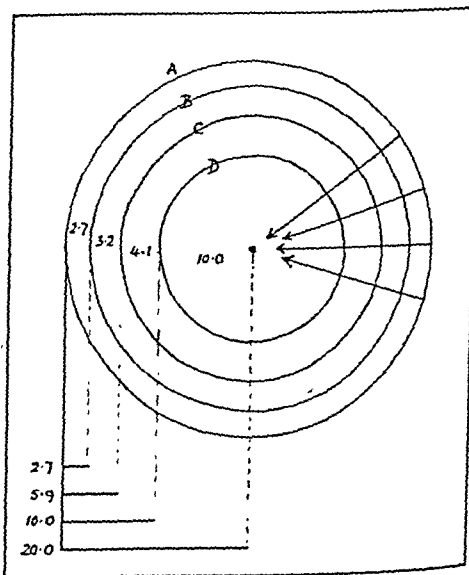


Fig. 2.—Chart showing increasing daily centripetal growth of epithelium, but with constant coverage, in experimental wounds.

rate of epithelization in rats under normal conditions. The fact that the average curve is a straight line, except during the first three or four days and at its termination, shows that the same percentage of the original area is covered per day, in spite of the fact that the length of the edge of new epithelium becomes progressively

7. Herrmannsdorfer, A.: *Deutsche Ztschr. f. Chir.* 200:534, 1927.

8. Reimers, C., and Winkler, H.: *Deutsche Ztschr. f. Chir.* 241:313, 1933.

shorter. Figure 2 diagrammatically represents the growth on three successive days. Each ring represents the epithelial edge at the beginning of each day. The areas between the rings are equal; i. e., they represent the total coverage each day. It is obvious, however, that the distance covered radially toward the center increases each day in inverse proportion to the length of the edge of new epithelium. What does this mean? Are the cells on the continuously diminishing edge proliferating proportionately faster in order to cover the same area, (proliferative activity increasing with time)? Or are the epithelial cells being pushed or migrating centerward? The latter supposition would imply that the proliferating cells are on the original periphery and do not change place, i. e., that the process resembles that in normal skin, in which the proliferating basal cells push the older cells toward the outer surface, whereas in wounds the old basal cells push the epithelium as a sliding sheet across the wound toward the center. The latter explanation is supported by the observations of Loeb,<sup>9</sup> who found the mitotic activity confined to the "back areas" (the original periphery), at some distance from the advancing epithelial edge.

Since our work has been completed, Henshaw and Meyer<sup>10</sup> have published their results, with an excellent summary of earlier work, which we have therefore omitted from this paper. We agree with them that the rate of proliferation of the basal cells is constant during most of the period of healing (represented by the straight part of the curves in figure 1) and that therefore the time of coverage of a long narrow wound would be determined by their formula  $T = \frac{L}{V}$ , in which  $T$  is the total healing time,  $L$  the initial breadth of the wound and  $V$  the rate of advance of the epithelial edge per day.

When, however, the wound is circular, or the periphery is short compared with the area, and the peripheral basal cells are pushing the epithelium toward the center (fig. 2) the increasing lateral pressure of the converging "columns" of cells would be expected to accelerate the forward movement of the "head" of each converging column," i. e.,  $V$ , or the distance traveled each day toward the center, to increase with time. Our experiments show this to be true. Their formula

therefore does not hold true for this type of wound.

Henshaw and Meyer<sup>10</sup> further stated that the healing of irregular wounds is a function of neither the length of the growing edge nor the area of the wound but of the diameter of the largest circle that can be described within the edges of the wound. The matter is not as simple as this. Since growth of the basal cells pushes out the epithelial sheets in a direction at right angles to the growing edge (shown by arrows at  $A$  and  $B$  in figure 3), it follows that at  $A$ , where the lines of growth converge, the distance traveled toward the center,  $C$ , will be considerably greater than the distance traveled from segment  $B$ , where the lines of growth diverge. It would seem that no simple formula will

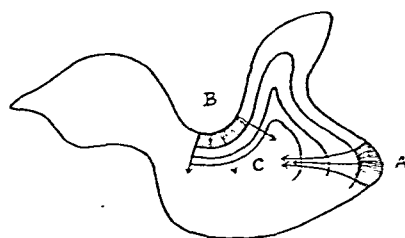


Fig. 3.—Drawing showing variations of centripetal growth of epithelium on convex and on concave segments of the periphery of a wound.

describe the time of wound healing unless the wound is of such a simple shape that the area can be readily calculated.

#### REGULATION OF GROWTH

Although we have no intention of discussing the various theories of growth and the factors regulating it—of which the best known are those of Carrell<sup>11</sup> and of Burrows<sup>12</sup>—certain interesting considerations arise from the foregoing observations.

One of these is the reason for the slowing down and final cessation of the growth of basal epithelial cells, represented by the flattening out of the terminal part of the growth curve (omitted from figure 1). As the growing cells push the enlarging epithelial sheet across the wound, especially when the lines of growth converge with an increasing lateral squeeze, resistance to, or pressure on, the proliferating cells must also increase. Since pressure on growing tissues elsewhere leads to diminution and cessation of

9. Loeb, L.: Arch. f. Entwicklungsmechn. d. Org. 297, 1898.

10. Henshaw, P. S., and Meyer, H. L.: J. Nat. Cancer Inst. 4:351, 1944.

11. Carrell, A.: J. Exper. Med. 15:516, 1912; Proc. Inst. Med. Chicago 8:62, 1930.

12. Burrows, M. T.: J. M. Research 44:615, 1924; Am. J. Anat. 37:289, 1926.

growth and even atrophy and, conversely, since the release of lateral intercellular pressure (as in wounds) leads to further growth, one would expect mutual cellular pressure to be a factor in some way regulating growth, probably by mechanically interfering with the inflow or supply of nutrient and growth-stimulating substances (creatine, sulphhydryl compounds, etc.) and with the outflow of waste products, which, as is known from observations on tissue cultures, diminish cellular growth. If these things are true, then healing wounds are self regulating.

#### CONCLUSIONS

From these considerations we conclude that (a) with a constant rate of epithelial proliferation, the area covered per day depends only on the length of the periphery of the wound; (b) for wounds with a high ratio of periphery to area (long, narrow wounds) a simple formula based on the breadth of the wound can be used for calculating healing time, and (c) for wounds with a low ratio of periphery to area (broad wounds) a formula based on the more complicated measurement of area must be employed.

# DIFFERENCES IN THE PATTERNS OF BITES OF VENOMOUS AND OF HARMLESS SNAKES

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Some students maintain that when a pit viper bites in self defense it merely sticks its fangs into the victim as a stab, whereas others insist that such a snake uses both its jaws in a true bite. Early reports of the last century, such as the classic ones of Weir Mitchell and Joseph Fayrer, vaguely describe pit vipers as actually biting, but the fact was not emphasized because then much more important aspects were crying for attention. Nearly all recent instructions for the treatment of snake poisoning flatly state

If a venomous snake leaves but two marks, there can be no doubt about its identity and just where the first aid cuts should be made; if many marks are left by either a poisonous or a harmless snake, the victim, already suffering from tremendous nervous strain, may be called on to exert considerable judgment in determining the nature of the bite and then, in case it is dangerous, finding the fang punctures.

In the United States, all poisonous snakes except two kinds of coral snakes are pit vipers.

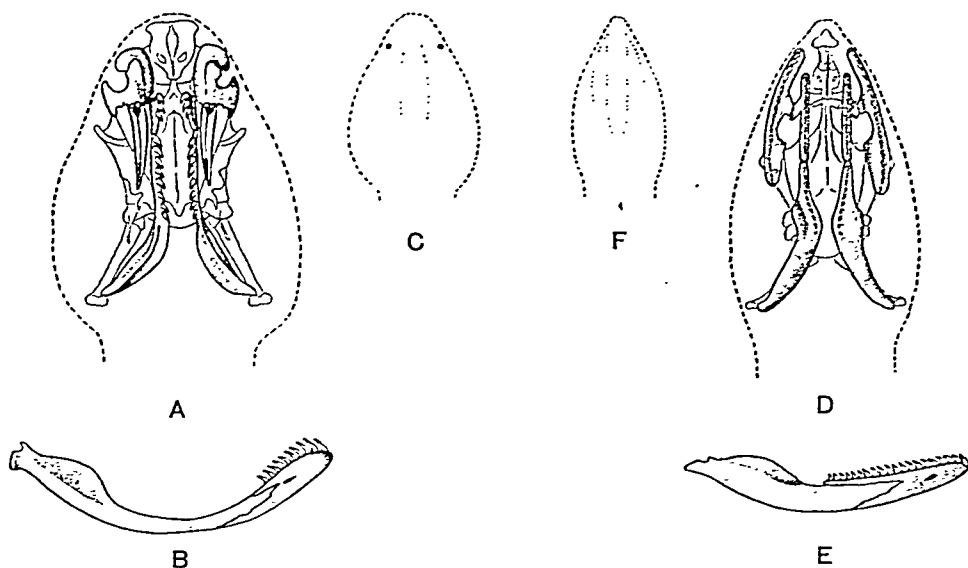


Fig. 1.—Teeth of a harmless snake compared with teeth and fangs of a venomous one. *A*, upper jaw of a western diamond-back rattlesnake seen from below, showing the fangs folded and the two rows of teeth lying between the fangs, each row being made up of three teeth on the palatine bone and eight on the pterygoid bone. *B*, side view of one arm of the lower jaw, with its ten teeth. *C*, diagram of the arrangement of the teeth and fangs in the same upper jaw, each fang being represented by a heavy black spot. *D*, teeth in the upper jaw of the bull snake, a harmless domestic species. The two inner rows are longer than in the rattler, since the bull snake has seven more teeth on the palatine and two more on the pterygoid bone. The bone that in the rattler serves as a base for the fangs carries sixteen teeth in the bull snake. *E*, one arm of the lower jaw, which has twice as many teeth as that of the rattlesnake. *F*, diagram of the arrangement of the teeth in the bull snake.

that the bite of a venomous snake leaves only one or two fang punctures and is therefore easily distinguished from that of a harmless one, with its six rows of punctures made by small teeth (fig. 1). The purpose of this paper is to settle the question, which has practical value in the treatment of snake poisoning as well as theoretic interest.

Since coral snakes never strike but inject their venom by seizing a victim at close range and chewing, they have been left out of consideration; obviously the pattern of their bite is a separate problem. The pit viper of the United States that inflicts the greatest number of serious bites is the western diamond-back rattlesnake (*Crotalus atrox*); hence this species was chiefly

used in the demonstrations. Conclusions based on it are no doubt valid for other rattlesnakes in the United States. The pit vipers of the United States lacking the rattle are the water moccasin (*Agkistrodon piscivorus*) and the copperhead (*Agkistrodon mokasen*), and a representative of each of these was also used to complete the list of domestic pit vipers. Since Klauber has suggested that some tropical American kinds bite in a somewhat different manner, it may be best to refrain from generalizing about pit vipers other than those of the United States.

All of the harmless snakes in the United States big enough to bite have four rows of teeth in the upper jaw and two in the lower. Figure 1 *D*, *E* and *F* shows the arrangement of the teeth in the bull snake (*Pituophis sayi*), a harmless species. Since the teeth in any one of the harmless snakes are usually similar in size, structure and shape, most of them come into

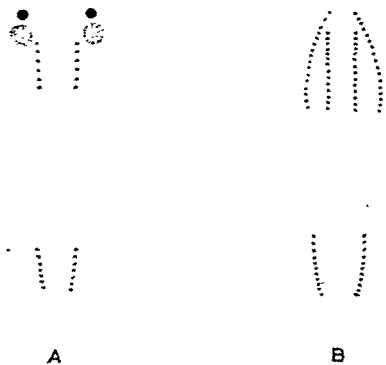


Fig. 2.—Diagrams of almost perfect bite patterns of a poisonous and a harmless snake. The stippled areas are approximately over the pockets of injected venom. *A*, western diamond-back rattlesnake. *B*, bull snake.

play during the act of biting and in a perfect bite leave six rows of punctures, four rows in one group and two in the other (fig. 2 *B*). In the pit vipers, the outer row on each side of the upper jaw has been reduced to a single large, erectile, hollow tooth, the fang. The bite of a pit viper, therefore, should leave not more than four rows of punctures in addition to the two large perforations made by the fangs (fig. 2 *A*).

If, in defending itself, a pit viper stabs rather than bites, only the fangs can come into play; if it actually bites, the two rows of small teeth of the upper jaw and the two of the lower will make their marks in addition to the fangs, which are much farther apart than the rows of teeth. Due allowance must of course be made for bites on finger and toe tips and for those that for various other reasons do not make discernible patterns. Interference by clothing may prevent

punctures by the teeth, but it is well known that bites through clothing are not nearly so dangerous as those encountering no such obstruction.

The first demonstrations were made with plasticine cylinders approximately the size of a human wrist. One cylinder, wrapped in a piece of soft, thin paper, was held in front of a rattlesnake, which in turn was lying on the bottom of a large container with sides of wire screening. Figure 3 shows the pattern made by the teeth of a Texas western diamond-back rattler (*Crotalus atrox*) measuring 39 inches (99 cm.) exclusive of the rattle. Eight teeth of the upper jaw as well as the fangs pierced the paper and entered the plasticine. Five teeth of the right side of the lower jaw made punctures, as did about as many of the left side; some of the impressions made by the teeth of this side were not separate. Venom that had spilled around the fang punctures was absorbed by the paper, as indicated by stippling in the figure. On each side, about midway between the punctures of the upper and lower jaws, distinct impressions of lip scales could be seen in the plasticine (fig. 3 *B*), showing that a considerable pull must have been exerted by the jaw-closing muscles. Such a bite is not a stab, nor does it leave only the punctures of the two fangs. Figures 1 *A* and 4 show the arrangement of teeth in the western diamond-back rattlesnake and will help any one to understand how a snake with a head only  $1\frac{9}{16}$  inches (4 cm.) long can get the teeth of the upper jaw so far from those of the lower. Since the movements of a snake in striking are faster than the human eye, the exact position of the jaws when they are seizing an object is unknown; the figure gives the approximate position only.

The plasticine cylinder was next held in front of the same snake but vertically instead of horizontally, to suggest the position of a leg in walking (fig. 5). The strike produced a pattern differing from the first in only a few points: The marks of the teeth of the upper jaw were a little farther from those of the lower, which indicated that the jaws were spread to their utmost and must have been at about an angle of 180 degrees. The axis of the bite was not vertical; this showed that the snake tilted its head slightly, as if to get a better grip on the almost flat surface confronting it. The marks of the teeth of the lower jaw ran together—proof that the jaw pulled them sharply upward as well as inward. This would be inevitable in a biting rather than a stabbing action. Moreover, the snake hit, in spite of the fact that an

object presenting an almost flat surface would be so much more readily stabbed.

Two cylinders of a plastic called "catabond" were next prepared. At the stage in which it

Texas was induced to bite this cylinder, with results as shown in figure 6. The water moccasin has more teeth in the upper jaw (five on the palatine bone and fifteen or sixteen on the

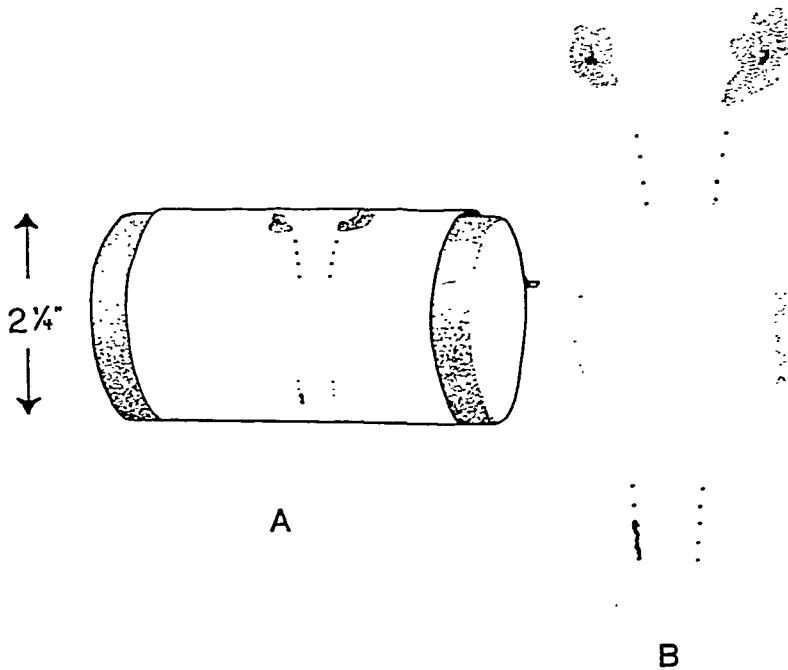


Fig. 3.—Bite pattern of a western diamond-back rattlesnake, made in a plasticine cylinder that was wrapped in thin paper and held horizontally in front of the snake. Stippling represents venom that was spilled on the surface around the fang punctures. On the left side, a replacement fang had become functional before loss of the old fang. In *A*, impressions of the lip scales are outlined by dots. Some of the punctures by the teeth are not separate. *B*, an enlargement of the same pattern flattened and showing in dotted outline impressions that were made through the paper in the plasticine by the lip scales. A few punctures on the lower left side are not separate.

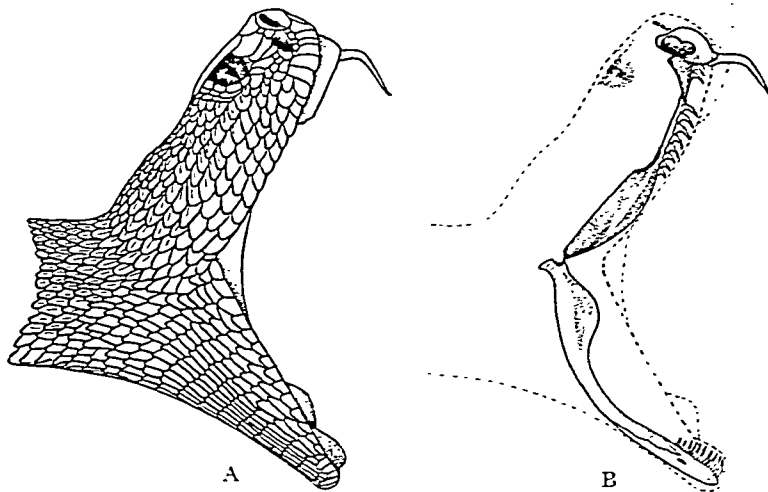


Fig. 4.—*A*, side view of the head of a western diamond-back rattlesnake, with mouth open and fang erect. *B*, phantom view of *A*, showing only the fang on the maxillary bone, the teeth of the upper jaw on the palatine and pterygoid bones and the teeth below on the end of the mandible.

is used, this material is about as resistant to pressure as human flesh. A 27 inch (68.6 cm.) water moccasin (*Agkistrodon piscivorus*) from

pterygoid bone on each side), as indicated by the greater number of punctures made in the cylinder. The lower jaw also has more teeth



serum seeping from the fang punctures. No one knows, of course, how many cuts have been made in the wrong place and how many bites by harmless snakes have been cut. There are numerous records of severe symptoms and even death following the bites of innocuous species thought by the victim to be venomous. The introduction of venom causes sharp pain, but an apprehensive person aware of this fact will often imagine pain after the bite of a harmless snake or even after the scratch of a thorn.

#### SUMMARY

The literature on snake poisoning is misleading in stating that a pit viper in biting makes only one or two large punctures, in contrast to the several rows of small ones made by a harmless snake. The reason for this is said to lie in a difference between the behavior of the two types of snakes; i. e. the pit viper merely stabs with its pair of long fangs, whereas the harmless snake actually bites. It is demonstrated here that pit vipers of the United States bite as effectively as most innocuous snakes; in no

sense do they merely stab. The bite pattern of the pit viper, though not simple, can be recognized. Moreover, a careful study of the bite may reveal the approximate location of the pocket of venom, the size of the snake and even its generic identity.

In dealing with any physical injury the first step is to make an exact analysis of it. In the case of snake bite, one must first determine whether one is treating actual snake poisoning or merely superficial scratches and pricks of a harmless snake. Physicians who report cases of poisoning should include diagrams of all marks made by teeth and fangs and thus help in the accumulation of data on bite patterns. Directions for the treatment of snake bite should explain the true difference between the patterns of harmless and venomous snakes and explain how interference by clothing will invariably modify both.

Miss Marie H. Pettibone drew all the illustrations. Miss Priscilla Hannaford gave general assistance and various colleagues of the Chicago Natural History Museum gave advice and technical suggestions.

## A REVIEW OF UROLOGIC SURGERY

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### KIDNEY

*Anomalies.*—Lowsley and Menning<sup>1</sup> report a case of pelvic single kidney, which brings the total number of reported cases of this anomaly to 36. In 13 of the 35 cases which have been reported previously, operation was performed on the kidney. Nephrectomy for supposed neoplasm was performed in 2 cases; obviously, death occurred in both cases. In another case in which operation was performed for tumor the kidney was punctured to obtain a specimen for biopsy and the patient died one week after the operation. Three patients were operated on for stone; 1 died five days after operation. One patient underwent nephrostomy for hydronephrosis. Thus, in 4 of the 13 cases the patients died after operation on the kidney. Most of the earlier deaths are attributable to failure of diagnosis, owing to lack of instrumental and roentgenographic facilities.

This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

1. Lowsley, O. S., and Menning, J. H.: Pelvic Single Kidney: Report of a Case, *J. Urol.* 51:117-127 (Feb.) 1944.

The average age of the patients in this series of cases was 25 years. The youngest was an 8 month fetus. Most of the patients were between the ages of 20 and 40 years. Only 1 was more than 47 years of age; this patient was 68 years old and died of pneumonia after pyelotomy was performed for stone. Genital abnormalities were present in 18 of the 36 cases.

In the case reported by these authors, the patient was a boy, 7½ years of age, who was hospitalized for infection of the urinary tract. Cystoscopy did not disclose any ureteral orifice on the left side. Retrograde pyelography disclosed a pelvic kidney lying over the upper portion of the sacrum. The ureter was dilated and tortuous and seemed to terminate abruptly at the intramural portion. A fifteen minute-delayed roentgenogram showed complete retention of the contrast medium. Surgical exposure revealed the ectopic kidney. The ureter was coiled and tortuous, particularly in its upper segments, and was moderately thickened. A metal probe was passed into the ureter. An incision was made over the probe, and the intramural segment of the ureter was dissected free from the bladder. The lumen of the intramural portion of the ureter was definitely stenotic. The kidney was drawn upward, and nephropexy was performed. About

8 cm. of the redundant ureter was excised. The stump of the ureter was drawn through the opening of the bladder and fastened there. The post-operative course was uneventful. A check-up fifteen months later revealed prompt excretion of the intravenously injected dye. The kidney was in good condition, and there was much less dilatation of the calices than there had been previously.

Culp and Hiebert<sup>2</sup> found congenital anomalies of the ureter in 23, or 3 per cent, of 747 cases in which pyelography was performed because of symptoms referable to the urinary tract. A great variety of anomalous conditions was encountered in this group of 23 cases.

In more than 50 per cent of the cases infection of the urinary tract, lithiasis or hydronephrosis was present. Since all of the patients were comparatively young, there is reason to suspect that secondary pathologic changes eventually may occur in other cases. From the available evidence, one must conclude that anomalous kidneys are more likely to be the site of disease than normally developed kidneys.

In 52.2 per cent of these cases the symptoms were due to secondary pathologic changes. When these changes were eliminated, most of the symptoms were relieved.

Nevertheless, some anomalies appeared to be capable of producing discomfort despite the absence of superimposed disease. This seemed to be true especially in cases of renal ectopia. In almost a third of the cases, however, the symptoms were not related to the anomalies.

Treatment consisted of chemotherapy for infection, ureteral dilatation and surgical removal for calculi and efforts to promote better renal drainage for hydronephrosis. Recurrences of these secondary pathologic changes are to be expected in some instances, and nephrectomy eventually may have to be done in some cases. Congenital anomalies of other systems were present in only 3 cases.

Because of the relatively high incidence of renal symptoms and secondary disease in cases of congenital anomaly of the upper part of the urinary tract, the anomaly must be evaluated cautiously and considered a source of potential urologic difficulty.

Exley and Hotchkiss<sup>3</sup> report a case of clear cell carcinoma of a supernumerary kidney. They say that a true supernumerary kidney, with an

individual blood supply and no anatomic connection to another kidney, is extremely rare. This rarity is readily explained when one considers the combination of embryologic circumstances necessary to effect this result. First, there must be an abnormal mesenchymal splitting so that two separate mesenchymal bodies are formed on one side. Then there must be simultaneously and independently a splitting of the ureteral bud as it elongates and migrates cranially on that side.

Forty-three cases of clear cell carcinoma of a supernumerary kidney have been reported, and the case reported by Exley and Hotchkiss makes a total of 44. These authors state:

The term supernumerary kidney should be reserved for the free accessory organ which is a distinct, encapsulated, large or small parenchymatous mass topographically related to the usual kidney by a loose cellular attachment at most, and often by no attachment whatsoever.

A preoperative diagnosis has been made only 3 times; in many of the cases diagnosis was made at necropsy.

The ages of the patients in the reported cases ranged from 9 months to 67 years. In most of the cases in which operation was performed the symptoms first occurred in the second decade of life, but the condition is prone to produce pathologic change in the kidney in early life. The incidence of the anomaly is equal in the two sexes. The extra kidney may be above or below the normally situated kidney, but it usually is below. Harpster said that the supernumerary kidney may be situated in the iliac region or in the pelvis. In 6 of the reported cases it was in the true pelvis. The supernumerary kidney is also smaller than the normal kidney unless there is an associated disease process.

In the majority of cases the ureters fuse somewhere in their course to the bladder. The most common point of fusion is a short distance above the ureterovesical junction. If there is no fusion of the ureter above the bladder and if cystoscopy reveals a right and left ureteral orifice in the bladder, a careful and diligent search may reveal an extravesical orifice.

In the case reported by Exley and Hotchkiss the patient was a man, aged 65 years, who complained of general weakness and an uncomfortable feeling in the lower part of his abdomen. Abdominal palpation revealed a movable, firm mass about 5 inches (12.7 cm.) in diameter, in the middle of the right side of the abdomen. Retrograde pyelography disclosed that the right kidney was comparatively normal; on the right side there were two kidney pelves, which were widely separated, and two separate ureters, which joined

2. Culp, O. S., and Hiebert, P. E.: Clinical Significance of Congenital Anomalies of the Kidney and Ureter, *J. Urol.* 51:397-403 (April) 1944.

3. Exley, M., and Hotchkiss, W. S.: Supernumerary Kidney with Clear Cell Carcinoma, *J. Urol.* 51:569-578 (June) 1944.

together about midway down their course to the bladder. With the patient under spinal anesthesia, the retroperitoneal region on the right side was explored. A large mass about 5 inches (12.7 cm.) in diameter was present in the lower of the two kidneys on the right side. The two kidneys were completely separate and had separate ureters. The lower kidney, because of its increased growth, had extended down behind the upper kidney. This lower kidney, with its contained mass, was removed. The diagnosis was supernumerary right kidney with carcinoma of the clear cell type.

Nation<sup>4</sup> says that the critical period in fetal life for development of ureteral duplication is the fourth week. Complete ureteral duplication results from the formation of two ureteral buds on one wolffian duct. Partial duplication results from bifurcation or cleavage of the renal pelvis and ureter.

This anomaly was encountered in 0.7 per cent of 16,000 cases in which necropsy was performed. In these cases, the age of the patients who had ureteral duplication did not differ appreciably from the age of other patients. In cases in which the diagnosis is made clinically, renal disease with ureteral duplication is likely to be discovered before middle life.

Ureteral duplication is 27 per cent more common in women than in men. Clinically, this anomaly is observed three times as frequently in women as it is in men. Unilateral ureteral duplication occurs three times as often as bilateral duplication. Unilateral duplication occurs with approximately equal frequency in the right and left ureters and in men and women. Bilateral duplication is approximately 10 per cent more common in women than in men and is observed more often clinically than at necropsy. Ten per cent more of unilateral duplications are incomplete than are complete; the exact reverse is true of bilateral duplications.

Bifurcation occurs with approximately equal frequency in all parts of the ureter. The incidence of renal disease discovered at necropsy is not influenced by ureteral duplication.

The most common pathologic lesions associated with this anomaly are infection, hydronephrosis and nephrolithiasis. The most common symptom is pain. The average blood pressure in this series of cases was lower than that in other cases in which the anomaly was not found at necropsy.

Higbee<sup>5</sup> states that hypoplasia seldom exists alone as a congenital anomaly. Often it is associated with epispadias, hypospadias and pseudohermaphroditism. In the past it has often been overlooked entirely, or if infection has complicated the situation it has been confused with chronic atrophic pyelonephritis.

Renal hypoplasia may be defined as a miniature or rudimentary kidney. It should be differentiated from two closely allied conditions: renal agenesis, in which no renal tissue is present, and renal aplasia, in which rudimentary renal tissue exists without a collecting system.

The distinguishing characteristics of the hypoplastic kidney are: (1) a thin rim of parenchyma usually can be visualized roentgenographically, and (2) it secretes urine of varying quality and amount, which is collected either by normal or bizarre calices or by a hydronephrotic or small bulbous renal pelvis and transferred to the bladder by a well formed ureter. It should also be distinguished from chronic atrophic pyelonephritis. This may be difficult if infection previously has been present. However, the contracted and irregular minor calices will usually stand out, in contrast with those of the congenitally small, smooth, normally formed kidney.

Owing to an unhealthy embryologic background, the hypoplastic kidney is more subject to infection than a normal one and frequently suffers from repeated or chronic infection, which alters the structure of the kidney, both grossly and microscopically. The glomeruli are usually small, though normal. A few may be found hyalinized, and the tubules are lined with low or degenerated epithelium. Some of the tubules that are lined with degenerated epithelium show cystic changes.

Weiss has observed that hypoplastic kidneys are more subject to pyelonephritis than kidneys of normal size and that chronic infection is more likely to persist. Therefore, one might expect an increased incidence of hypertension with infected hypoplastic kidneys. This, however, has not been observed by Higbee. Nephrectomy, when performed, has usually been necessitated in order to relieve either pain or infection. No cases have been encountered in which nephrectomy has been performed with the expectation of curing the accompanying hypertension.

The most common non-nephritic lesions in the order of their decreasing frequency were: (1) atrophic forms of pyelonephritis, including those following previous renal operations, (2) renal

4. Nation, E. F.: Duplication of the Kidney and Ureter: A Statistical Study of Two Hundred and Thirty New Cases, *J. Urol.* 51:456-465 (May) 1944.

5. Higbee, D. R.: Congenital Renal Hypoplasia Associated with Hypertension: Report of Two Cases, *J. Urol.* 51:466-475 (May) 1944.

neoplasm, (3) renal lithiasis, (4) hydronephrosis, (5) renal tuberculosis and (6) polycystic kidneys.

The best results from operation were obtained in cases of atrophic pyelonephritis with advanced cicatricial changes in the tissues. In 60 per cent of these cases recovery occurred. The second most successful results were obtained in cases of renal tuberculosis associated with hypertension. Recovery occurred in 50 per cent of these cases. Complete recovery occurred in 25 per cent of the cases in which stone and hydronephrosis were associated with hypertension.

Nation<sup>6</sup> states that renal aplasia usually results from failure of proper contact between the ureter and the metanephros. True renal aplasia was found in 16 of 27,000 necropsies. The incidence of the condition in this series was about the same as that of renal agenesis. "In 3 cases the anomaly was bilateral. The right and left kidneys were involved with equal frequency. Nine of the patients were males, and 7 were females. Six of the 9 patients who lived more than one month died as a result of hypertension; each had extensive disease of the functioning kidney. Four patients, 3 females and 1 male, had developmental defects of the genital tract. Renal aplasia can seldom be distinguished clinically with certainty from renal agenesis. Operation is indicated for the following conditions: (1) pain, (2) intractable hypertension with no evidence of disease of the functioning kidney and (3) hypertension in which pyelonephritic contracture or renal hypoplasia cannot be excluded.

**Tumor.**—Herger and Sauer<sup>7</sup> report data on 100 consecutive patients with cortical tumor of the kidney. Seventy-three of the patients were admitted to the hospital with inoperable, recurrent or metastatic lesions, and 27 patients had early or moderately advanced tumors. At the time of the report only 4 patients were alive and apparently well; 11 were alive but still had the disease, 10 could not be traced, 4 had died of other causes and 71 had died of the disease. Operation offers the only chance of cure provided the tumor is still operable. External irradiation is of little or no value in the majority of cases, because parenchymal neoplasms of the kidney are radioresistant. Some of the patients with cortical tumors of the kidney may have symptoms for many years prior to admission to the hospital.

These patients may live for a considerable length of time before they succumb to the disease.

Loeb<sup>8</sup> reports a case of Wilms tumor in a woman, 49 years of age, who at the onset had some discomfort in the right flank, which developed into severe pain in the right lumbar region. Bilateral pyelograms showed a normal left kidney, but gross enlargement of the shadow of the right kidney over the upper pole with elongation and distortion of the superior calices. The communicating portion was also filled with the contrast medium. These findings indicated a cystic mass in the upper pole of the right kidney. There was also bilateral calcification of the ligaments connecting the spinal column with the wing of the ilium. A cardiogram was normal. The kidney was removed, and convalescence was uneventful.

Ockerblad and Carlson<sup>9</sup> report a case of Wilms tumor with an eight year cure. The patient was 11 weeks old when first seen. On examination a large mass was found in the left side of the abdomen. A plain roentgenogram and intravenous pyelograms showed normal renal pelvic outlines on the right except for a bifid renal pelvis. On the left side there was no evidence of renal function. A mass occupied the renal region on this side and had displaced the stomach upward and the colon to the right. The left kidney was removed through a subcostal incision. The large tumor mass had replaced the kidney almost entirely. Convalescence was uneventful. The patient was given roentgen therapy for twenty-five days only. Microscopic examination indicated that the growth was a Wilms tumor.

Wood<sup>10</sup> reports a case of Wilms tumor in a Filipino, 45 years of age. The clinical course of the disease from the onset of symptoms lasted seventeen months, the last fourteen of which was spent continuously in the hospital. Histologically, this tumor showed much variation in structure. It consisted of rather well differentiated epithelial structures, resembling abortive tubules and glomeruli, and myoblastic structures manifesting a lesser degree of differentiation. Some of the metastatic lesions were almost entirely sarcomatous. In such nodules, however, cross striations in the muscle cells could be found only infrequently. Longitudinal myofibrils were more numerous than cross striations. Many of the cells contained "dustlike" material.

8. Loeb, M. J.: Report of a Case of Wilms' Tumor in an Adult, *J. Urol.* 50:268-273 (Sept.) 1943.

9. Ockerblad, N. F., and Carlson, H. E.: Wilms' Tumor with Report of an Eight-Year Cure, *J. Urol.* 50:265-267 (Sept.) 1943.

10. Wood, D. A.: Adenomyosarcoma of the Kidney in the Adult (Wilms' Tumor), *J. Urol.* 51:23 (March) 1944.

6. Nation, E. F.: Renal Aplasia: A Study of Sixteen Cases, *J. Urol.* 51:579-586 (June) 1944.

7. Herger, C. C., and Sauer, H. R.: Cortical Kidney Tumor—Analysis of One Hundred Consecutive Cases, *Surg., Gynec. & Obst.* 78:584-590 (June) 1944.

plasmic granules. An accurate diagnosis was not made until completion of studies made at necropsy. Intravenous pyelograms made early in the disease gave uniformly negative results and were noncontributory toward indicating the kidney as a possible source of the disease. The only urinary abnormalities consisted of mild transient hematuria and pyuria at the beginning of the disease. Dull pain in the lumbar region constituted one of the earliest, most persistent and outstanding symptoms.

Melicow<sup>11</sup> reviews 199 cases of renal tumor observed at the Squier Urological Clinic. Nephrectomy was performed in 162 cases. In the majority of the remaining 37 cases the lesion was inoperable. The diagnosis was based on observations made by roentgenography, biopsy or autopsy.

Renal neoplasms are more common in men than in women; the ratio of men to women is .5 to 1 (140 men to 59 women).

Neoplasms occur with about equal frequency in the two kidneys. Tumors of the left kidney in Melicow's series predominated in the inoperable group and in the group of highly malignant mixed tumors in both adults (4 on the left to 1 on the right) and infants (6 on the left to 3 on the right).

In 137 cases, or about 70 per cent of the total cases of renal neoplasm, the tumor occurred when the patients were between 41 and 70 years of age. In 69 cases the tumor occurred when the patients were between 51 and 60 years of age. The only tumors encountered in the third decade were relatively benign papillary tumors of the renal pelvis. Half of the mixed tumors in the adults occurred in the fourth decade. All the Wilms tumors in the series (9 cases) were seen before the fifth year.

Painless hematuria was the earliest and most common complaint. From the point of view of the pathologist, it is a late symptom, as it denotes vascular apoplexy due to a well established growth.

The most common symptoms or signs in the order of their frequency were painless hematuria, pain referable to the renal region and a mass. A mass was the presenting symptom in cases in which the tumor was advanced and inoperable. In the majority of these cases, loss of appetite and weight, chills and fever, leukocytosis and secondary anemia were also present.

<sup>11</sup> Melicow, M. M.: Classification of Renal Neoplasms: A Clinical and Pathological Study Based on One Hundred and Ninety-Nine Cases, *J. Urol.* **51**: 33-385 (April) 1944.

In cases of tumor of the renal pelvis, a constant filling defect observed in repeated pyelograms was suggestive. In cases of early clear cell carcinoma the characteristic pyelogram showed elongated thinned calices. In cases of more advanced tumor and granular cell carcinoma and mixed tumor, there were in addition, distortion and obliteration of some or of all the calices. Scattered dots of calcium were suggestive of deposits of lime in an old hemorrhage within a tumor or cyst or both and were usually found in lesions of long standing.

The papillary pelvic tumors tended to grow slowly, and those which were relatively benign occurred in the younger age groups (third decade). Some grew along the ureter and into the bladder. In a number of cases the tendency for subsequent development of papillary neoplasms in the ureter, bladder and urethra was suggestive of a neoplastogenic proclivity of the epithelium of the entire urinary tract.

The nonpapillary pelvic tumors were of the metaplastic squamous cell variety with "epithelial pearl" formation. They tended to become ulcerated and covered with calcareous debris or calculi. They usually invaded the kidney. Fever and leukocytosis were present.

Parenchymal tumors occurred in any portion of the kidney and grew in all directions. Those near the pelvis tended to invade it and the hilar structures. Those near the renal capsule tended to grow through it into neighboring tissues. The larger and heavier the tumor, the worse, as a rule, was the end result. When gross breaking of barriers or hemorrhage was found, local invasiveness and distant metastasis were likely.

The so-called Grawitz tumors, or hypernephromas, were usually clear cell carcinomas arising apparently from the epithelium of the tubules or from clear cell adenomas. They were yellowish and circumscribed. True hypernephromas, of adrenal rest origin, were rare.

The so-called hypernephroid carcinomas were usually granular cell carcinomas or adenocarcinomas arising apparently from the epithelium of Bowman's capsules or of the glomerular tufts or from the granular cell adenomas. They were grayish, infiltrating and devoid of a capsule.

The mixed tumors of the kidney in adults were usually carcinomatous centrally and sarcomatous peripherally. This probably was indicative of a highly active metaplasia or anaplasia. The mixed tumors in infants were usually carcinosarcomas and were apparently of dual origin.

It was at times impossible to distinguish microscopically a papillary carcinoma of the pelvis which had diffusely invaded the kidney from a clear cell carcinoma with papillary formation of

similar invasiveness, from a granular cell carcinoma involving the entire parenchyma or from a papillary cyst carcinoma which had penetrated the capsule and spread out.

Multiple adenomas, multiple cystadenomas or multiple papillary cystadenomas were usually secondary findings in a sclerotic kidney. The bilateral nature of the disease in some of the cases was suggested by the postoperative course and proved by autopsy.

The grading of renal tumors, except those arising in the pelvis, is not feasible. Amitosis is the rule. Prognosis depends on the duration of symptoms (the longer, the worse), the character of the presenting symptoms (the presence of the three most common symptoms or their reversal is a bad omen) and the size of the tumor (the larger and heavier tumors are usually more malignant). Other adverse factors are the breaking of gross and microscopic barriers and the presence of hemorrhage and secondary changes.

The prognosis for parenchymal tumors is progressively worse from: (a) the uncomplicated single nodule of clear cell carcinoma to (b) the multiple nodules of clear cell carcinoma with hemorrhages to (c) the granular cell carcinoma to (d) the mixed cell tumor.

The advent of metastasis is a matter of lymphatic or vascular penetration by tumor cells. While the incidence for local recurrence and metastasis increases progressively in the foregoing groups, nevertheless occasionally a small clear cell carcinoma, usually near the hilar region, may metastasize early, while a huge cystic mass containing tumor may remain sharply localized for a long time.

Rottino and Mohan<sup>12</sup> report 3 cases of hemangioma of the kidney. In 2 of the cases diagnosis was made when nephrectomy was performed, and in the third case it was made at necropsy. The first 2 cases comprise the only instances of renal hemangioma in 169 cases in which nephrectomy was performed in ten years at St. Vincent's Hospital (New York). The third case comprises the only instance of renal hemangioma in 1,650 cases in which necropsy was performed. Riley and Swan did not find a single case of this tumor in 13,219 cases in which necropsy was performed at the Boston City Hospital. Study of removed kidneys impressed Rottino and Mohan with the insignificant size of hemangiomas and with their obscure situation. Their true nature was realized only after careful microscopic study. This fact makes questionable

the presumed rarity of renal hemangioma. Indeed, in the absence of hematuria many these tumors must pass unnoticed.

Shaheen, Cassano and Lisa<sup>13</sup> review 30 cases of primary carcinoma of the kidney in which necropsy was performed. These cases comprise about a fourth of all the instances of primary renal tumor found in 5,100 autopsies. Primary renal tumor was more frequent among males than females. It usually occurred beyond the sixty year of life. The clinical triad of hematuria, pain and palpable tumor occurred in about a sixth of the cases. In about an equal number of cases, tumor mass was the only clinical sign. The presenting symptoms were as frequently caused by metastatic or embolic processes as they were by genitourinary disturbances. In a fourth of the cases, the malignant lesion was unrelated to the clinical disease or to the cause of death. Retrograde pyelography was the most valuable of the diagnostic laboratory procedures. Carcinoma of the kidney is of renal origin and does not originate from adrenal rests.

**Trauma.**—Adlington<sup>14</sup> reports a case of traumatic rupture of the kidney and spleen with dislocated pelvis. The patient, a man aged 3 years, had a severe accident in a steel mill. Directly after his hospitalization, there was severe abdominal pain, which caused vomiting. The preoperative diagnosis was ruptured left kidney with intraperitoneal hemorrhage. A catheterized specimen of urine contained some blood. Exploratory operation disclosed a large rent in the peritoneum of the left paracolic gutter, and a small pyramidal-shaped piece of kidney was mopped out of the peritoneal cavity. The kidney was severely lacerated and was removed. The bleeding still continued, and palpation of the spleen revealed severe laceration of this organ. The spleen was then removed and the abdomen closed. The patient recovered from the operation; he could walk well and was free of pain before his dismissal from the hospital. Desjard and others (1930) reported nearly a 50 per cent recovery rate with combined nephrectomy and splenectomy in 46 cases of concomitant rupture of the spleen and the left kidney.

Meltzer,<sup>15</sup> in searching the literature, found reports of 18 authentic cases of true traumatic hydronephrosis. He reports a case of giant-sized hydronephrosis, which illustrates the importance

13. Shaheen, A. L.; Cassano, C., and Lisa, J.: Primary Tumors of the Kidney, *J. Urol.* 51:57-61 (June) 1944.

14. Adlington, S. R.: Traumatic Rupture of Kidney and Spleen, with Dislocated Pelvis, *Brit. J. Surg.* 3:497-498 (April) 1944.

15. Meltzer, M.: Giant Hydronephrosis Following Generalized Trauma, *J. Urol.* 51:491-495 (May) 1944.

12. Rottino, A., and Mohan, H.: Renal Hemangioma: An Obscure Cause of Hematuria, *J. Urol.* 51:601-605 (June) 1944.

of carrying out urologic examination when there is a history of an old injury to the abdomen or the back. Months or years later the only subjective symptoms may be vague and mild backache, abdominal pain or a sense of fulness and weight in the abdomen, with or without urinary symptoms. A large hydronephrotic sac may be present for some time, and yet the patient may have no discomfort or localizing pain.

**Stone.**—Thompson, Steadman, Benjamin and Scott<sup>16</sup> made a quantitative chemical analysis of 47 human urinary calculi, which revealed that 78 per cent were of the calcium oxalate-phosphate type, 16 per cent contained magnesium as a significant component, either alone or in combination with a calcium phosphate, and 6 per cent were composed predominantly of uric acid.

Evidence has been cited to indicate that among calculi of the oxalate-phosphate type, the heavier calculi contain more phosphate, while those of lighter weight are relatively richer in oxalate. The variation in proportion of oxalate to phosphate is without significant effect on the percentage of calcium, which is nearly constant at about 25 per cent. This finding does not hold for the three component stones. Small amounts of nitrogen from an unidentified source are consistently found, and the percentage of this is unrelated to the weight of the calculus. The general observation that urinary calculi consist predominantly of more than one component has been confirmed.

Quantitative spectrochemical analyses made on 1 mg. samples of the stones verified the principal findings of the chemical analyses and, in addition, showed the occasional presence of traces of other common elements, such as lead, copper, manganese, silver, bismuth and sodium.

Infection was more frequently associated with magnesium ammonium phosphate stones than with calcium oxalate-phosphate calculi.

No relationship was found between the type of infection and the chemical constitution of the renal calculi analyzed.

In selected cases, no vitamin A deficiency was found.

Farman<sup>17</sup> reports a case of bilateral nephrolithiasis in a horseshoe kidney. A man, aged 36 years, complained primarily of backache. A roentgenogram showed extensive bilateral nephrolithiasis. Pyelograms revealed that the

right renal pelvis was completely filled with a large stone, that there was an impassable obstruction of the upper part of the left ureter and that multiple calculi were scattered throughout the left renal area. A left anterior pyelolithotomy and nephrostomy were performed, and 38 stones were removed. One month later, a right pyelolithotomy and nephrostomy were performed. Cystoscopy, done three weeks later, revealed that both ureters were open.

Farman states that factors influencing the formation of calculi are more frequently evident within the fused (anomalous) kidney than in the normally formed kidney. In reported cases, a calculus has been the most commonly found concomitant lesion. Extreme caution, full knowledge of anatomic relationship and great appreciation of operative and clinical hazards should motivate all approach to surgical correction of the anomalous or fused type of kidney and associated pathologic changes.

**Rickets.**—Hayward<sup>18</sup> discusses the syndrome known as renal rickets. As the title implies, rachitic changes are present. They are assumed to be caused by renal dysfunction. The syndrome is found among young persons; the average age of patients at the time of onset of symptoms is 12½ years. Hayward describes a typical case.

The following signs and symptoms may be noted before the patient is 13 years of age: The average height is 24.2 per cent below normal, and the average weight is 45.2 per cent below normal. Signs and symptoms may or may not lead to an examination of the urinary tract. Mentality is good. Bony changes develop; genu valgum or knock knees are present in 56 per cent of the cases. Other bony changes are less constant. The roentgenographic findings are typical of ordinary rickets. Thirst, polyuria, dryness of skin, loss of appetite, headache and delayed sexual development are present, depending on the severity of the renal involvement. Laboratory studies show poor renal function, azotemia and, most important of all, a reversal of the calcium-phosphorus ratio. Of the preceding symptoms, the three outstanding diagnostic points are dwarfism, rachitic changes and reversal of the calcium-phosphorus ratio.

The type of renal impairment is unimportant. Obstruction of the urinary tract, nephritis, congenital cystic disease or other changes can initiate the train of events. Practically all contributors on the subject agree on one thing, namely that the kidney is unable to excrete phosphorus. This accounts for the high value

16. Thompson, H. E.; Steadman, L. T.; Benjamin, A., and Scott, W. W.: Quantitative Microchemical and Spectrographic Data on Renal Calculi and Their Relation to Infection, *J. Urol.* 51:259-271 (March) 1944.

17. Farman F.: Bilateral Nephrolithiasis in Horseshoe Kidney, *J. Urol.* 51:447-455 (May) 1944.

18. Hayward, W. G.: The Renal Rickets Syndrome, *J. Urol.* 51:278-286 (March) 1944.



for the serum phosphorus. The phosphorus is eliminated into the bowel, where it combines with calcium to form insoluble calcium phosphate, which the bowel cannot absorb. As a result, a calcium deficiency occurs.

Not only is exogenous calcium prevented from entering the system, but endogenous calcium is being removed by parathyroid action.

The daily requirement of calcium during growth is from 0.4 to 1 Gm. or more. Calcium phosphate comprises 80 per cent of bone. Bone is the reservoir of both calcium and phosphorus, and these are constantly being added to or drawn from bone. Acidosis, which is present with this syndrome, ionizes enough free calcium to keep its level above 3.8 Gm.

Any renal lesion so severe as to cause failure of excretion of phosphorus may be present. Albright and others stated that parathyroid cells are not as large in this type of hyperparathyroidism as they are in primary hyperparathyroidism. As for bony changes, Albright and his co-workers clearly explained that they are due to secondary hyperparathyroidism and consist of swollen metaphyses, bony replacement with fibrous tissue, cysts and hemorrhage. Genu valgum, deformity of the thorax, rachitic rosary, a wooly appearance of the skull and fractures may be present.

The symptoms associated with lowered renal function vary, as would be expected, and consist of headache, anorexia, nausea, vomiting and increased thirst. In several of the cases reported in the literature the stature remained small and there was no bony deformity until adolescence, when the patients began to grow rapidly. Genu valgum developed at this time.

The syndrome rarely can be treated successfully. It may be postulated that if treatment is to be successful the renal lesion must be of the obstructive type and the patient must be seen before irreparable renal damage has occurred.

It is obvious that nephritis severe enough to cause this syndrome must offer a poor prognosis, as must polycystic disease. The seriousness of this condition can best be brought home by stating that necropsy was performed in almost all of the comparatively large number of cases reviewed. The duration of life is almost two years after bony changes occur.

**Infection.**—Munger<sup>19</sup> says that cortical abscesses and renal carbuncles are distinct pathologic and clinical entities. These conditions frequently are difficult to diagnose. A careful study of the history, with inquiry into antecedent superficial infection, and of the physical and

roentgenologic findings usually will enable one to make a correct diagnosis. Adequate incision decapsulation and drainage usually are curative. The sulfonamide drugs are definite adjuncts.

**Function.**—Baumrucker<sup>20</sup> found that after the injection of contrast substances for excretory pyelography the specific gravity of the urine increases in proportion to the concentration of the dye. There is a close parallel between visualization of the kidney and increase in the specific gravity of the urine after the injection of diodrast solution. This increase in specific gravity allows computation of the amount and percentage of dye excreted. The author has devised an equation for calculating renal function. While excretory pyelography enables one to determine the concentrating ability of the kidney, the equation supplies the numerical equivalent, or the percentage of the contrast medium excreted. In pyelograms, kidneys that are unable to concentrate urine sufficiently to cause an added rise in the specific gravity of the excreted urine of 0.018 (as from 1.024 to 1.042) after injection of diodrast solution usually will not appear as clearly as will kidneys that are able to effect such a concentration. Good pyelograms are dependent on the preparation of the patient and on the pyelographic technic. To the factor of dehydration and evacuation may be added third, namely gravity. The author has modified the customary technic by placing the patient in Trendelenburg position of 25 to 30 degrees. This facilitates filling of the renal pelvis and hence permits better visualization of the kidneys.

**Thrombosis.**—Melick and Vitt<sup>21</sup> report a case of thrombosis of the renal vein. The patient was a woman, aged 33 years, who complained of chills, fever and pain in the right side of the thorax and back. Cystoscopy revealed that the bladder was normal but that no urine came from the right ureter. Ureteral catheters were passed on both sides without difficulty. There was no drainage on the right side. The right renal pelvis was poorly visualized and irregular in outline on retrograde pyelograms; the left kidney was normal. Exploratory operation revealed that the right kidney was considerably larger than normal. Palpation of the pedicle revealed thrombosis of the renal vein. The kidney was removed.

In adults thrombosis of the renal vein may be due to primary hematogenous pyelonephritis with resultant thrombosis within the renal vein and extension to the pedicle. It also may

19. Munger, A. D.: General Aspects of Acute Surgical Infections of the Kidney. *South. M. J.* 37: 20-23 (Jan.) 1944.

20. Baumrucker, G. O.: Estimation of Renal Function Based on Specific Gravity Changes Following Excretory Urography. *J. Urol.* 50:290-300 (Sept.) 1943.

21. Melick, W. F., and Vitt, A. E.: Thrombosis of the Renal Vein. *J. Urol.* 51:5-7-566 (June) 1944.

due to involvement of the pedicle by infection, from rupture of either a cortical abscess or a perinephritic abscess. The thrombosis of the renal vein may be part of a progressive, ascending inflammatory process involving, first, the vessels of the pelvis or lower extremity and, then, the inferior vena cava and its higher branches. In infants, the thrombosis is almost always secondary to severe ileocolitis or gastrointestinal upsets. In 1 infant, the thrombosis was secondary to primary pneumonitis.

The onset is usually sudden: there are fever, pain and tenderness on the affected side. On palpation, the kidney has been found to be enlarged in every case reported so far. The kidney is also freely movable and extremely tender. Usually there are signs of infection and severe toxemia. Frank hematuria or microscopic hematuria has been present in almost every case.

Surgical removal of the kidney seems to be the treatment of choice. Nephrectomy or attempted nephrectomy was employed in 14 cases of thrombosis of the renal vein. Ten patients recovered, and 4 died. However, in cases in which operation was not performed, no patients recovered although some lived for several months. The operation seems to be more successful the earlier it is performed. Campbell and Matthews found an abnormally prolonged prothrombin time in 2 infants. For this reason they stressed the importance of administration of vitamin K. For adults it would seem more rational to use substances such as heparin or dicoumarin to prolong the prothrombin time and prevent, if possible, further extension of the thrombotic process.

*Diagnostic Value of Overdistention of the Renal Pelvis.*—Wattenberg and Rose<sup>22</sup> found that overdistending the renal pelvis with fluid through a ureteral catheter will produce pain unless the pelvis previously has been subjected to back pressure of some degree for a long time. Such back pressure causes desensitization, that is, it is a process of physiologic adaptation. Pain arising in the renal pelvis often is referred atypically. Such referred pain cannot be reproduced, but the central pain can be reproduced. Nonirritating fluids should be used, water preferably. Irritating fluids cause generalized ureteral spasm and cloud the picture. Reproducing ureteral pain by passing a ureteral catheter is not a reliable test, although it may be of value at times. A blocked pelvic or ureteral muscle goes through stages of compensation (irritability and hyperplasia) and decompensation (desensitiza-

tion and overstretching). Generally, however, with exceptions, colicky and intermittent pain is associated with the hyperirritable stages, and dull, heavy costovertebral pain is associated with a dilated renal pelvis. The patient must state that the overdistention is accurately reproducing his pain; otherwise, the test is of doubtful value. Wattenberg and Rose have found the test nearly 100 per cent accurate when considered with the preceding exceptions. It frequently indicates the subsequent treatment.

*Operations and Postoperative Complications.*—Flo and Cummings<sup>23</sup> report a case in which unilateral decapsulation of the kidney was performed for transfusion oliguria. The patient was a woman, aged 48 years, who after transfusion had a greatly decreased urinary output and a concentration of 118 mg. of nonprotein nitrogen per hundred cubic centimeters of blood. As she was in poor general condition, a unilateral decapsulation only was done. She seemed considerably better immediately after operation. Her vomiting ceased, and she was more alert. Intravenous administration of fluid was continued, and urinary secretion commenced at once. The first twenty-four hour period produced 211 cc. of urine and the second 625 cc.

Flo and Cummings state that the exact mechanism is not clearly understood but deserves investigation: if unilateral decapsulation will break the vicious chain of events, it is the procedure of choice.

Wilhelm,<sup>24</sup> in discussing reimplantation of the renal pelvis, states that the most favorable results have been observed after the Y plastic or the side to side anastomosis, which preserves the physical continuity of the pelvis and ureter. Sometimes, however, this type of operation is not feasible because of shortness of the ureter, as in cases of traumatic avulsion or extensive stricture. In this event, an end to end anastomosis is made between the sectioned ureter and the pelvis.

In a review of 11 cases in which the ureter was reimplanted into the renal pelvis, 7 instances of partial or complete occlusion at the site of anastomosis a short time after operation were found. The anatomic cause of obstruction was determined in 3 of these cases.

With the recognition that simple end to end anastomosis over a splinting catheter is likely to result in loss of continuity or in stricture, various technics have been suggested in an attempt to

23. Flo, S. C., and Cummings, H. W.: Unilateral Decapsulation of Kidney for Transfusion Oliguria, *Surgery* 14:216-222 (Aug.) 1943.

24. Wilhelm, S. F.: Reimplantation of the Renal Pelvis, *J. Urol.* 50:274-277 (Sept.) 1943.

22. Wattenberg, C. A., and Rose, D. K.: Reproduction of Renal Overdistention Pain: Its Clinical Diagnostic Value, *J. Urol.* 50:280-289 (Sept.) 1943.

insure patency of the stoma. Most practical of these is splitting the upper end of the ureter for 1 cm. into two straps. The ureter is then implanted into the pelvis and the straps sutured to its inner surface. A splinting catheter and a nephrostomy tube are left in place. The ureteral straps, however, may become loose and form an occluding rosette or valve, which will interfere with the downward flow of urine.

In order to prevent the formation of an obstructive valve, a technic was planned in which the renal pelvis is implanted into the ureter. The upper end of the ureter is split for 1 cm. into two straps. These straps are placed and sutured outside the renal pelvis. The anastomosis is made over a splinting catheter, and nephrostomy and nephropexy also are performed. If the externally sutured ureteral straps should loosen, they would not obstruct the newly made stoma.

Wilhelm reports a case in which a man 51 years old entered the hospital on July 2, 1942 for removal of 4 calculi from the left kidney. At operation, the ureter was found embedded in thick, infiltrated fat and adhesions; it was sectioned transversely. Four calculi were removed from the renal pelvis and calices, and a Malecot nephrostomy tube and a Garceau catheter were inserted through the renal cortex into the pelvis.

The upper end of the ureter was split into two straps, each 1 cm. in length. The Garceau catheter was then passed down the ureter for 12 cm. and acted as a splint. The renal pelvis was reimplanted into the ureter, and the ureteral straps were sutured to the external surface of the pelvis by four interrupted sutures of fine chromic surgical gut. A nephropexy was done.

After removal of the splinting Garceau catheter on the twenty-fourth postoperative day, indigo carmine was injected into the nephrostomy tube and appeared promptly in the vesical urine. On the twenty-ninth postoperative day, the nephrostomy tube was clamped off. The wound remained dry for the next six days, and there were no untoward symptoms. The tube was removed on the thirty-fifth postoperative day, and within seventy-two hours the sinus was closed and dry. The patient left the hospital on the following day and has been well since that time. The wound remained healed. On September 10, an excretory urogram revealed fair function in both kidneys and slight dilatation of the pelvis of the left kidney. A left retrograde pyeloureterogram also showed some dilatation of the renal pelvis. Although the site of anastomosis was marked by an indentation, the stoma was widely patent and there was no retention of the contrast medium.

Caughlan and Boler<sup>25</sup> discussed the value of two stage nephrectomy. They deliberately planned and carried out two stage nephrectomy on several patients and found that it was no less hazardous than single stage nephrectomy.

One patient had a tumor of the left kidney. The kidney was exposed at the first operation and four days later it was removed.

The second patient was a girl, aged 14 years who had a large Wilms tumor of the kidney. She was given roentgen therapy and supportive therapy before operation. A two stage nephrectomy was done transperitoneally. At the first stage, the kidney was exposed and the vascular pedicle ligated. At the second stage, twenty-four hours later, the original incision was opened, the pedicle religated and the kidney removed in short time.

Caughlan and Boler state that in their opinion both of these patients would have died had operation been carried out in one stage. They suggest that two stage nephrectomy might be carried out in cases of pyonephrosis or renal tuberculosis or in any case in which nephrectomy would require a long time.

Hayward<sup>26</sup> presents a case in which hypertension developed promptly after a plastic operation on a hydronephrotic kidney. The blood pressure immediately returned to normal after removal of the kidney. It is reasonable to believe and it is borne out in practice, that the more promptly unilateral nephrectomy is performed in selected cases after the advent of hypertension the better the chance of cure. In a large number of cases in which conservative renal operations are performed, the kidney becomes fixed in scar tissue. This may cause renal ischemia by pressure on the parenchyma or by compression on the pedicle. Blood pressure should be carefully watched after conservative operations on the kidney.

Lazarus<sup>27</sup> states that gas bacillus infection complicating operation on the upper part of the urinary tract is rare. Only 25 cases of this complication have been reported, including the one reported by him. Although gas bacillus infection may be due to a variety of organisms, the predominant one is *Bacillus welchii*.

While the usual incubation period varies from one to six days, the average being three days, the infection has been known to occur as soon

25. Caughlan, G. V., and Boler, T. D.: Two-Stage Nephrectomy, *J. Urol.* 51:481-485 (May) 1944.

26. Hayward, W. G.: Renal Surgery as a Cause of Renal Ischemia, *J. Urol.* 51:486-490 (May) 1944.

27. Lazarus, J. A.: *Bacillus Welchii* Infection Complicating Surgical Procedures upon the Upper Urinary Tract, *J. Urol.* 51:315-324 (March) 1944.

as a few hours after operation and as long as ten years after inoculation. The outstanding clinical features of this infection are rise in temperature and pulse rate, severe toxemia, edema and pain in the wound and typical purplish discoloration of the surrounding skin, followed later by coalescing blebs. The diagnostic features are crepitation in the subcutaneous tissues and serosanguineous discharge, with a typical sweetish, mousy odor. Smears and cultures will disclose *Bacillus welchii*. Smears may be positive within six hours and cultures within four hours after the onset of infection.

Treatment consists of wide open drainage and generous use of oxygenized antiseptic solutions, along with polyvalent *Bacillus perfringens* serum. Judging from the cases reported by Lazarus, it appears possible that sulfonamide drugs administered locally and orally are coming to play an important role in the prophylaxis and actual treatment of this type of infection. Roentgen therapy has been advocated in the early stages of the disease. In the reported cases, 71.4 per cent of the patients recovered. Of the patients who recovered, 73.3 per cent received serum. Of the 6 patients who died, 2 died before any treatment could be given and the remaining 4 received serum.

The kidney was the source of infection in 23 (92 per cent) of the 25 cases reported, and the ureter was the source of infection in 2 cases (8 per cent). The following operations preceded the infection: nephrectomy in 45.4 per cent, nephrotomy in 18.1 per cent and pyelotomy in 22.7 per cent of the cases respectively. Calculi were present in 15 (60 per cent) of the cases: renal calculi were present in all 15 and ureteral calculi in 2. In 6 of these 15 cases pyonephrosis also was present. Renal infection necessitating nephrectomy was present in 11 cases (44 per cent), and in 5 cases the infection was associated with calculi.

In the first of the 2 cases reported by Lazarus, a fulminating infection followed the removal of multiple calculi, one of which was fragmented. Clinical evidence of infection appeared seven hours after operation. In the second case, pyelolithotomy was performed for a single calculus which was not fragmented. In this case, sulfadiazine had been administered because of pulmonary involvement immediately after the operation. The first indication of infection of the wound occurred forty-eight hours after operation.

In view of the fact that the opening in the renal pelvis was not sutured after removal of the calculus and since the calculus was removed intact, it is extremely likely that the escape of infected urine from the kidney into the wound played an important role in the development of this complication. For this reason, it is suggested that in cases of renal or ureteral calculi openings made in the ureter or renal pelvis should be closed tightly, particularly if the calculi are accompanied by urinary infection.

Schneider<sup>28</sup> reports a case of postnephrectomy duodenal fistula with recovery, along with 3 additional cases in which the patients died. Two cases in which a fecal fistula occurred after removal of the right kidney is reported to show that this complication also may occur. Treatment of the duodenal fistula may be: (a) conservative, which may be systemic and local, or (b) radical, either immediate or late, depending on the patient and the surgeon. Schneider concluded that if the meager figures presented are any indication at all there is practically no difference between the results of conservative and radical treatment, the mortality being about the same for both. Complications may sometimes be avoided by performing subcapsular instead of extracapsular nephrectomy.

Taylor and Taylor<sup>29</sup> report a case in which duodenal fistula followed nephrectomy. The patient was a man, aged 30 years, who had had an operation on the left kidney for the removal of stones. Three weeks later an operation had been performed on the right kidney for the same reason. Several months later reexamination revealed good function in the left kidney, but no function in the right kidney. A short time later a bulging abscess was found in the region of the right kidney. The abscess was drained. Six months later the right kidney was removed. The kidney was adherent to all surrounding structures. Three days after the operation, a slight greenish tinge was noticed in the drainage from the wound. The drainage increased, and it evidently came from the duodenum. The wound was protected, and owing to the basic condition no effort was made to close the fistula, which continued to drain for forty days and finally healed.

28. Schneider, D. H.: Duodenal Fistula After Kidney Surgery, *J. Urol.* 51:287-295 (March) 1944.

29. Taylor, C. B., and Taylor, J. M.: Duodenal Fistula Following Nephrectomy: Case Report, *J. Urol.* 50:278-279 (Sept.) 1943.

## PROGRESS IN ORTHOPEDIC SURGERY FOR 1943

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY  
OF ORTHOPAEDIC SURGEONS

### XII. CONDITIONS INVOLVING THE FOOT AND ANKLE

PREPARED BY EMIL D. W. HAUSER, M.D., CHICAGO, AND ROBERT P. MONTGOMERY, M.D., MILWAUKEE

Stevenson<sup>434</sup> gives a review of the common disorders of the foot that cause disability in the army. The most important are those due to static changes, but he also brings out some of those due to rare tropical diseases. The importance of vascular changes as well as the occurrence and treatment of dermatomycosis is included. The treatment of common injuries, such as sprains and puncture wounds, is clearly presented.

Dredge<sup>435</sup> takes up the common disabilities of the foot that occur in the army and groups them into four classifications: the traumatic, the mechanical static, the occupational, which include vascular disturbances, and the dermatologic, principally trichophytosis. The treatment for the disabilities is classified and does not materially vary from the accepted methods.

Fripp<sup>436</sup> brings out the fact that chronic and acute foot strain are not specifically wartime disabilities, but an army marches and a nation works largely on its feet, so that if there are any predisposing factors the increased strain of war work may cause a partial or complete breakdown. In the treatment of chronic foot strain he uses physical therapy methods, and for acute foot strain he emphasizes the need of rest and then heat and massage and faradic stimulation. If there is persistence of pain he uses an injection of 2 per cent solution of procaine hydrochloride.

The article also includes the treatment of crush injuries, lacerations and compound fractures. Immediate excision of the cutaneous edges is recommended. Primary closure should be attempted only if operation is carried out within eight hours after injury and if the cutaneous edges can be brought together without tension.

In his opinion, repeated application of closed plaster casts is the accepted method of after-treatment. For fractures he recommends the unpadded, closed plaster cast and warns of the danger of interference with circulation. He advises the sparing use of narcotics, so as not to mask the danger signs in the first twenty-four hours.

[ED. NOTE.—The after-treatment of open wounds by means of a closed cast is still a question. The difference of opinion is primarily due to the different circumstances surrounding the cases. In the African campaign the open method was proved to be the method of choice, whereas in the Russian campaign the circumstances were such that the closed method was preferable. These circumstances include the comparative organization of transportation facilities for immediate care as well as the type and number of bacteria that may be encountered.]

Lake<sup>437</sup> notes a vicious circle of "foot strain as a factor producing fatigue in industry and the Services" and "industry and the Services as factors producing foot strain and fatigue." He suggests that foot strain can be prevented by keeping the weight distributed as it should be and by avoiding undue continuous strain on the connective tissues, particularly the ligaments and fascia of the sole. The problem of foot strain in the services is different, for here the foot breaks down as a result of excessive activity and movement. Suddenness of change to military life is a factor. He advises more gradual methods of training. He points out that the problem of foot fatigue is complicated, demanding study of each case individually; no stereotyped measures can be expected to constitute a shortcut to relief.

Hellebrandt, Nelson and Larsen<sup>438</sup> have made a study to determine whether there is significant

434. Stevenson, A. S.: The Management of Disabilities of the Feet in the Army, *M. Clin. North America* **27**: 1129-1153 (July) 1943.

435. Dredge, T. E.: Physical Treatment of Disabilities of Foot Commonly Encountered in Military Service, *Arch. Phys. Therapy* **24**:653-659 (Nov.) 1943.

436. Fripp, A. T.: Some Common Wartime Disabilities of Feet, *M. Press* **208**:347-350 (Nov. 25) 1942.

437. Lake, N. C.: Foot as Factor Producing Fatigue in Industry and the Services, *M. Press* **208**:344-347 (Nov. 25) 1942.

438. Hellebrandt, F. A.; Nelson, B. G., and Larsen, E. M.: The Eccentricity of Standing and Its Cause, *Am. J. Physiol.* **140**:205-211 (Nov.) 1943.

antecedence for the volitional use and the difference in strength and size of the limbs of the two sides of the body. Their study was conducted first to find out if there was a preference for either limb. They repeated the method of Irwin and corroborated his findings. They also tested the strength and then measured the volume of the limbs by submerging them in fluid and measuring the displacement. They measured the morphologic symmetry by balancing the body on a movable platform suspended from the edges of knives. The result of their experiment shows that there is a slight preponderance of choice for the right foot in the preference test. They arrived at the following conclusions from their evidence: Morphologic and functional asymmetries occur in limb preference, volume and strength. Although most of the observed asymmetries are too small to have statistical significance, they constantly favor the right side. It is suggested that in the aggregate these small dextral asymmetries in functional capacity associated with like differences in strength and size have the effect of a slightly eccentric counterweight on the incessantly shifting rotatory movements acting on the joints of the weight-bearing skeletal parts.

[ED. NOTE.—This scientific investigation may lead to some clinical significance. In our clinical experience the left foot gives more trouble than the right. The significance of their findings in relation to our clinical experience is still undetermined.]

Carrell<sup>439</sup> enumerates the following as the causes of instability of the foot: a short first metatarsal, a hypermobile first metatarsal segment, metatarsus primus varus and accessory scaphoid or prehallux. He discusses Freiberg's disease and calcaneal apophysitis as well as the use of the Denis-Browne splint.

Lapidus<sup>440</sup> takes issue with the long-held belief that the longitudinal arch of the foot acts as a spring. He shows that the plantar fascia stretches only a small percentage of its length with weight bearing, so that there will be sagging of the apex of the arch of only 0.1 cm. The arch, in his opinion, is a developmental response to the functional requirement for increased strength of the foot as a lever. The integrity of the longitudinal arch is maintained by ligamentous

rather than by muscular structures. The muscles of the legs further the support of the longitudinal arch by maintaining a balance between the leg and the foot, by keeping the weight-bearing line in plumb line.

[ED. NOTE.—This is an excellent study, and we are in accord with his conclusions.]

Cuttle<sup>441</sup> found that it was difficult to establish the functional ability of a foot by examination and simple physiologic tests. He used the Osgood apparatus for measuring the relative powers of the abductor and adductor groups of muscles. His findings in a study of several hundred recruits corresponded with the clinical observations reported by Osgood. He feels that it may be of assistance in eliminating recruits with disabilities of the foot from the services.

[ED. NOTE.—We feel that this is a good approach, but there are other factors that are not considered when only the difference in the strength of muscles is measured.]

Leavitt<sup>442</sup> concludes that the os calcis type of flatfoot may be defined as a postural deformity of the foot in which apparently valgus or eversion of the rear portion of the foot initiates and is responsible for the subsequent deformities associated with depression of the longitudinal arch. Functional deformity of the os calcis type of flatfoot without abnormal congenital protrusion or deformity of the head of the astragalus and especially of the scaphoid can be prevented by subtalar arthrodesis. Symptoms of decompensation or foot strain accompanying this type of flatfoot can most satisfactorily and permanently be corrected by subtalar arthrodesis. It is sometimes necessary to remove the abnormal prominence of the scaphoid.

[ED. NOTE.—Flatfoot always starts with valgus at the heel, caused by decompensation. For that reason if the decompensation is eliminated the valgus is corrected. Our feeling, therefore, is that the foot should be fused in the normal position only when the decompensation cannot possibly be corrected by conservative measures, and in our experience this is rare.]

Crisp<sup>443</sup> is of the opinion that the primary cause of valgus strain is fatigue of the tibialis anticus muscle. He talks about contributing factors, however, such as faulty posture, adoles-

441. Cuttle, T. D.: Method for Evaluating Muscle Balance in So-Called "Flat-Foot" in Recruits for the Navy, U. S. Nav. M. Bull. 41:216-219 (Jan.) 1943.

442. Leavitt, D. G.: Subastragaloid Arthrodesis for Os Calcis Type of Flat Foot, Am. J. Surg. 59:501-508 (March) 1943.

443. Crisp, E. J.: Mechanics of Valgus Foot Strain, Proc. Roy. Soc. Med. 36:606-607 (Sept.) 1943.

439. Carrell, B.: Diagnosis and Treatment of Foot Deformities in Children, Texas State J. Med. 38:509-511 (Dec.) 1942.

440. Lapidus, P. W.: Misconception About "Springiness" of Longitudinal Arch of Foot: Mechanics of Arch of Foot, Arch. Surg. 46:410-421 (March) 1943.

cence, overweight and in the army heavy boots and long marches. He states that pain results from stretching of the plantar fascia. It is his opinion that the tibialis anticus muscle becomes completely suppressed and the extensor digitorum longus muscle tries to take over the action as a supporter of the longitudinal arch. This results in a clawing of the toes. Therefore there is a muscular incoordination, which he feels it is absolutely essential to rectify. This is done by having a masseuse persuade the patient to relax, train him to dissociate the tibialis anticus muscle from the extensor digitorum longus muscle and teach him to contract the tibialis anticus muscle again.

[ED. NOTE.—We do not agree with the premise that the primary cause of foot strain is fatigue of the tibialis anticus muscle. In our opinion, foot strain is caused by an imbalance between the capacity of the foot to do its work and the load that is placed on the foot. Therefore our therapeutic measures would differ also.]

Billig and Brennan<sup>444</sup> approach the problem of common disorders of the foot by describing a novel type of treatment in 94 cases. They stretched the fascial ligamentous structures of the iliotibial band and of the ligamenta flava. A 1½ inch (3.8 cm.) luggage belt is used to strap the patient firmly to the table, the strap being placed just distal to the anterior superior iliac spines in order to prevent the pelvis from tilting on the spine. The affected leg is adducted and flexed, while the knee is kept extended. They found that this procedure would elicit exacerbation of pain in the foot. They devised some methods and exercises for stretching the ligaments.

[ED. NOTE.—We have recognized a definite relationship between contractures of the ligaments of the thigh and ligaments of the back and mechanical disorders of the foot, and this relationship is on a basis of a functional decompensation, which is present in all these weight-bearing structures. That correction of one will influence another is to be expected.]

Robinow, Johnston and Anderson<sup>445</sup> made a thorough study by means of roentgenograms and accurate measurements of the height of the arches in children from the ages of 4 to 10 years, with and without weight bearing. The conclusion was that most children's arches change but little with age.

Rizzo<sup>446</sup> brings out the importance of women wearing proper shoes when working in indus and he describes what he considers a good st In addition, he advises exercises for strength ing the feet.

Childress<sup>447</sup> emphasizes that the pathologic changes associated with march fracture are synonymous with those in march foot. March fracture may occur in bones other than the of the foot. It occurs in the tibia, in the fib near the proximal or distal end of the bone and in the femur in the distal portion of the shaft and at the neck. Occasionally march fracture may develop in the pelvic bones. He reports a case of march fracture in the cuneiform bone and this is the first case that has been reported. The lesion is produced by repeated minor trauma, which by summation causes an overloading of the functional capacity of an otherwise normal bone. The therapy is rest.

Telford<sup>448</sup> describes vascular disturbances, including frostbite, immersion foot, trench foot and shelter foot. Their pathologic features are identical, differing only in the degree of damage. Exposure to cold is the main factor, but prolonged immersion plays an important role. In the majority of cases recovery was good, with no, or at the worst trivial, loss of tissue. In the other cases the patients continued to suffer from symptoms which were due to a combination of sclerosis and deficient blood supply. The after troubles most often found are pain of a burning or tingling type, increased by warmth or exertion, persistent indurated swelling, chronic and painful ulcers and loss of movement of fingers and toes. Occasionally there is a sensitization to cold. Hyperhidrosis may be troublesome also. These end results are in fact those of a vascular occlusion and resemble closely those found in thromboangiitis obliterans.

In his experience the best method of testing vascular efficiency in the lower extremities is to use a thermocouple thermometer provided with eight or ten leads, each carrying a point for application to the skin. These points are fixed on the areas selected for observation, and a movable plug allows the current from any one point to be recorded by the reflecting galvanometer. The temperatures are recorded, with the patient on the operating table, and at the

444. Billig, H. E., Jr., and Brennan, R. L.: Foot Pains, *Mil. Surgeon* 92:539-542 (May) 1943.

445. Robinow, M.; Johnston, M., and Anderson, M.: Feet of Normal Children: Study of Lateral X-Rays of Weight-Bearing Foot, *J. Pediat.* 23:141-149 (Aug.) 1943.

446. Rizzo, P. C.: Foot Symptoms: Instruction and Exercises for Their Relief, *Indust. Med.* 12:780-81 (Feb.) 1943.

447. Childress, H. M.: March Fractures of the Lower Extremities, *War Med.* 4:152-160 (Aug.) 1943.

448. Telford, E. D.: Sympathectomy in Treatment of Cryopathies, *Brit. M. J.* 2:360 (Sept. 18) 1943.

end of half an hour's observation of temperature a spinal anesthetic is given and the temperatures again recorded. The normal rise of temperature (14 to 18 degrees F.) in the feet in a young healthy adult is of the order of 8 to 10 degrees C. but in cases such as those under discussion a rise of 1 degree C. (1.8 degree F.) would justify sympathectomy, which can be carried out forthwith.

[ED. NOTE.—For the persistent type of vascular disturbance sympathectomy is of use, but most types respond to conservative measures.]

O'Donoghue<sup>449</sup> has for many years made it a practice at the Crippled Children's Hospital to carry out an operative fusion of the interphalangeal joint of the great toe in all cases of transplantation of the extensor hallucis tendon to the dorsum of the foot. It has been observed that bony fusion of this joint actually occurs in only a comparatively small percentage of these cases. To get bony union he obtained better fixation by careful denudation of the cartilaginous surface of the interphalangeal joint. Then with the toe in satisfactory position a Kirschner wire was drilled linearly through the end of the toe, traversing the distal phalanx, crossing the denuded joint and extending well into the proximal phalanx. This fixation resulted in more frequent bony union.

Goodwin and Swisher<sup>450</sup> discuss the treatment of congenital hyperextension of the fifth toe, with the toe in a markedly adducted position. They advise operation. A Y-shaped incision is made at the base of the involved toe on the dorsum of the foot. The branches of the Y extend diagonally distalward about halfway around the toe. The incision is carried down to expose the extensor tendon. A knife is passed through the tendon, making a horizontal slit about 2 cm. long. The tendon is divided by placing the blade of the knife in the slit and cutting through half of the tendon at the proximal end of the slit and the other half at the distal end of the slit. This is the usual Z-plasty used for lengthening of tendons. The joint capsule is exposed and simply cut at least 180 degrees around the joint. If the original deformity is mainly hyperextension, then the capsulotomy is done mainly on the dorsum. However, if there is severe adduction in the deformity, then the capsulotomy must extend well down on the medial side of the joint.

The toe should be freely movable and should assume a normal position without forcing. The toe is placed in this position and maintained there while the severed tendon is repaired; plenty of lengthening is allowed, so that the tendon is loose when the toe is in the normal or slightly flexed position. No repair of the capsule is done.

[ED. NOTE.—In those cases in which there is a tendency for recurrence of adduction, the abductor muscle should be transplanted to retain the position of the toe.]

Hammond<sup>451</sup> describes a procedure for correction of equinus contracture of the great toe. He describes the deformity as being principally due to an elevation of the head of the first metatarsal bone; in other words, there is a dorsal displacement of the head of the first metatarsal bone. Therefore, to correct the flexion of the great toe he brings the first metatarsal bone back to normal position. After the realignment of the first metatarsal bone he fuses it to the cuneiform bone. If there is displacement of the cuneiform also he fuses the cuneiform to the navicular bone. He uses a bone graft extending from the scaphoid to the cuneiform or to the base of the first metatarsal bone. If the flexion deformity is fixed he manipulates the toe to obtain correction.

[ED. NOTE.—This is a rational procedure to correct the deformity. In some cases correction can be obtained by the comma-shaped bar with an inclined plane, which brings the head of the metatarsal bone down to the correct position. If the contracture is so severe that it cannot be corrected conservatively, then osteotomy may be necessary to correct the deformity.]

Pruce and Hagen<sup>452</sup> describe 8 cases of clawing of the great toe resulting, in their opinion, from improper application of a plaster cast. They have also seen the condition following poliomyelitis and with Friedreich's ataxia. They stress the importance of prevention of the condition, emphasizing that a cast should always go up under the tips of the toes and be molded well to retain the normal arches. The occurrence of this deformity delays recovery.

[ED. NOTE.—In view of this article, it may still be necessary to emphasize that a cast should always go up to the tips of the toes on the plantar surface.]

449. O'Donoghue, D. H., and Stauffer, R.: Improved Operative Method for Obtaining Bony Fusion of Great Toe, *Surg., Gynec. & Obst.* **76**:498-500 (April) 1943.

450. Goodwin, F. C., and Swisher, F. M.: The Treatment of Congenital Hyperextension of Fifth Toe, *J. Bone & Joint Surg.* **25**:193-196 (Jan.) 1943.

451. Hammond, G.: Elevation of First Metatarsal Bone with Hallus Equinus, *Surgery* **13**:240-256 (Feb.) 1943.

452. Pruce, A. M., and Hagen, W. H.: Clawing of Great Toe Following Improper Application of Plaster, *J. A. M. A.* **123**:955-956 (Dec. 11) 1943.



Mair<sup>453</sup> reports an unusual case of plantar dislocation of the head of the fourth metatarsal bone. The mechanism of injury is not understood. It was treated by operative reduction.

A suggestion is presented by Jergesen<sup>454</sup> to prevent the concomitant occurrence of a valgus deformity of the normal foot during treatment of unilateral congenital talipes equinovarus with the Thomson modification of the Denis-Browne splint. He flexes the uninvolved hip to about 90 degrees and then adjusts the plate. After the adjustment he observes that the normal foot assumes the position of slight inversion, regardless of the position the leg may assume.

[ED. NOTE.—This is a recommendation for those who use the Denis-Browne splint.]

Morris<sup>455</sup> has treated with skeletal traction 52 recurrent clubfeet, 3 acquired clubfeet and 6 cavus feet. All the patients were children between the ages of 2 to 12 years. He recommends skeletal traction as a method that is relatively atraumatic and quick. He runs Kirschner wires through the tibia, the os calcis and the necks of the metatarsal bones. The wire through the tibia is inserted at the junction of about the upper and middle thirds of the tibia. Distraction is applied along the axis of the foot and maintained with a metal apparatus. Rods connect the Kirschner wires. The apparatus is illustrated, showing threaded distracting rods. He was able to obtain good corrections but was not able to retain them. His results showed failure to maintain correction in 40 per cent of the feet treated, which was due to deformity of the tarsal bones by too vigorous previous treatment. He does not believe that skeletal traction itself is a cure for deformities of the foot but believes that it can overcorrect the contractures. The maintenance of correction depends on completeness of the overcorrection as well as holding the foot in the overcorrected position for a sufficient length of time.

[ED. NOTE.—In our opinion, better results should be obtained by the usual conservative measures, so that there is not such a high percentage of recurrences. Even after recurrence, manipulative correction has given much better results in our hands than this type of treatment.

453. Mair, G. B.: Plantar Dislocation of Fourth Metatarsal, *Brit. M. J.* 2:169 (Aug. 7) 1943.

454. Jergesen, F. H.: Treatment of Unilateral Congenital Talipes Equinovarus with Denis-Browne Splint, *J. Bone & Joint Surg.* 25:185-187 (Jan.) 1943.

455. Morris, R. H.: Skeletal Traction as Method of Treatment for Certain Foot Deformities, *Arch. Surg.* 46:736-742 (May) 1943.

For severe deformities we use the Hagl board abetted by the Thomas wrench to correct the heel.]

Bohnsack and Andes<sup>456</sup> report the results of treatment in 302 cases of sprained ankle. In some cases they strapped the ankle and permitted early use, and in other cases they sprayed with ethyl chloride and permitted early use. The ankles which were strapped were soaked in ice-cold water for thirty minutes before strapping if they were seen immediately. They find that instead of using ethyl chloride it would be just as well, if not better, to use local injection of procaine hydrochloride.

Pennal<sup>457</sup> describes simple sprains and recommends injection of procaine hydrochloride, the adequate strapping and early functional activity. If the sprain is severe with rupture of the anterior and middle bands of the external lateral ligament, a momentary subluxation of the astragalus should be suspected. Aids in diagnosis are evidence of tilting of the astragalus on roentgenograms taken with the heel in extreme varus. The treatment requires prolonged immobilization by means of a walking cast, in most cases for about ten weeks. In cases of recurrent subluxation the diagnosis is made by rocking the astragalus and confirmed by roentgenograms taken with the foot held in inversion. In his series of cases Pennal used an outside crooked and elongated heel or an inside iron and T strap. The other alternative was an operative reconstruction of the external lateral ligament. He prefers the Watson-Jones technic.

Roberts<sup>458</sup> draws attention to the fact that in cases of sprained ankle the astragalus is sometimes tilted, as seen in roentgenograms taken with the heel fully inverted. In these cases recovery is slow and unsatisfactory, so that a sprain is sometimes worse than a fracture. He describes the ligaments which may be torn in the sprain, either the internal or the external lateral ligament, and he tells how to protect the ligament by means of zinc oxide or adhesive tape strapping. For chronic sprains in which there are a weak ligament and recurring displacement he advises an operation, usually in which an external lateral ligament is made from the peroneus brevis tendon. With regard

456. Bohnsack, R. W., and Andes, J. E.: Ankle Sprains: Incidence, Treatment, Diagnosis and Time Incurred, *Indust. Med.* 12:588 (Sept.) 1943.

457. Pennal, G. F.: Subluxation of Ankle, *Canad. A. J.* 49:92-95 (Aug.) 1943.

458. Roberts, N.: Treatment of Minor Injuries of Ankle, *Post-Grad. M. J.* 19:7-11 (Jan.) 1943.

to the injection of procaine hydrochloride in the treatment of sprains, he feels that there is remote danger of sepsis and also danger that the true nature of the injury may not be recognized. He feels that the chief values of procaine is its capacity to make the injured point painless, so that one can have a free hand to test clinically and roentgenographically for any potential instability.

Leinwand<sup>459</sup> describes a method of injection of procaine hydrochloride for the treatment of sprains, and as contraindications he names open wounds, infection or potential infection in the injured area, rupture of a large or medium-sized vessel and idiosyncrasy to the drug. He advocates the procedure for general use in military practice, particularly in the field or in landing forces, where the materials necessary may be incorporated in a field medical kit. He believes that it is a safe and convenient aid to maintain a policy of keeping as many men at as many guns as many days as possible.

McMaster<sup>460</sup> believes that recovery from sprain of the ankle is greatly hastened by active and continued use of the joint, regardless of what other local treatment is adopted. Injection of procaine hydrochloride makes possible early motion and elimination of pain. Over 90 per cent of sprains of the ankle involve the anterior alofibular ligament. Roentgenograms should be taken before treatment is started, to exclude fractures.

Bakst and McCormick<sup>461</sup> use local anesthesia or sprains of the ankle and also recommend it or injuries of the chest and back. Immediate and complete relief of pain makes it possible for the patient to get back to work sooner and also reduces the necessity for sedatives and narcotics. He recognizes the fact that it cannot be used for open wounds.

Smart<sup>462</sup> emphasizes the importance of maintaining the physiologic activity of muscles at its maximum in the treatment of strained muscles and sprained joints, particularly in the early stages. He discusses the complication of injury

to soft structures and advises graduated painless contractions produced by electrical stimulation immediately after the injury, which will result in beneficial physicochemical changes. In the later stages of injury, when muscles have become atonic and wasted, a point may be reached at which only limited muscular contraction can be initiated voluntarily. In such cases the beneficial effect of graduated contractions produced by electrical stimulation has only to be seen in order to bring full realization of the inestimable value of this method of treatment of muscles.

Outland<sup>463</sup> states that injuries to the anterior inferior tibiofibular ligament without serious fractures are frequent. If subluxation accompanies a sprain, disability always follows. In the early treatment he uses an unpadded walking cast. For a chronic condition he suggests the use of a bone graft taken from the tibia of the same side. Then a hole is driven through the tibia and fibula and the bone graft inserted.

Burns<sup>464</sup> brings out the fact that there is a good deal of trouble in the treatment of the abduction fracture of the ankle, and he feels that it is due to rupture of the tibial fibular ligament and diastasis. To correct this diastasis he first used a bolt driven through the tibia and fibula above the ankle. He now uses wire inserted through two parallel drill holes.

[ED. NOTE.—Our feeling is that the injection of procaine hydrochloride is of value, particularly in those cases in which it is certain that the injury is minor, in other words, a tear of the ligament that can heal in normal position with weight bearing. It is particularly useful inasmuch as it relieves pain and muscular spasm. In some instances muscular spasm persists, owing to irritation of the injured ligament, and holds the foot in valgus. With injection of procaine hydrochloride in these cases the foot can go back to normal position, and spontaneous recovery will occur. The dangers of the injection method, as has been pointed out in the articles reviewed, are in addition to the contraindications the fact that it masks the real lesion and may permit the occurrence of a serious deformity. In cases of severe ligamentous tear there frequently is tearing of the tibiofibular ligament. If this ligament is torn and not protected by accurate fixation, diastasis occurs, which becomes

459. Leinwand, I.: The Use of Local Anaesthesia in the Treatment of Sprains (or Local Tissue Injury Without Open Wounds), *Mil. Surgeon* 92:60-62 (Jan.) 1943.

460. McMaster, P. E.: Treatment of Ankle Sprain: Observations in More Than Five Hundred Cases, *J. A. M. A.* 122:659-660 (July 3) 1943.

461. Bakst, H. J., and McCormick, G. W.: Use of Local Anesthesia in Treatment of Contusions and Sprains, *U. S. Nav. M. Bull.* 41:107-111 (Jan.) 1943.

462. Smart, M.: Early Treatment of Strains and Sprains by Graduated Muscular Contractions, *Brit. J. Phys. Med.* 6:76-81 (May-June) 1943.

463. Outland, T.: Sprains and Separations of the Inferior Tibiofibular Joint Without Important Fracture, *Am. J. Surg.* 59:320-329 (Feb.) 1943.

464. Burns, B. H.: Diastasis Fracture of Inferior Tibiofibular Joint, *Proc. Roy. Soc. Med.* 36:330-332 (May) 1943.

permanent and causes disability. The early recognition of this lesion and proper treatment prevent future trouble. Our chief use of the injection, aside from eliminating muscular spasm, is to aid in diagnosis. With the injection method for the painful sprain, the foot can be brought into extreme inversion or eversion and instabilities can be detected that would not ordinarily show in the routine roentgenograms.]

McElvenny<sup>465</sup> states that Morton's toe is often resistant to conservative treatment. It is caused by a tumor involving the most lateral branch of the medial plantar nerve. Careful palpation will usually reveal the tumor, which lies high in the web between the third and fourth toes. If symptoms justify it, excision of the tumor should be done. The author reports on 11 patients treated by operation. Of the 12 tumors removed from 11 patients, 5 had been studied microscopically and appeared to be either neurofibromas or angioneurofibromas. Grossly they were fatty and soft on the outside and firm, white and fibrous toward the center. The plantar nerve was embedded in the center.

Hauser<sup>466</sup> reports a case of neurofibroma of the deep plantar nerve, which is a rare tumor. At the time of resection he emphasizes that sufficient nerve be removed so that the section is done through normal nerve tissue, to lessen the chances of recurrence. The term "neurinoma" avoids the implications as to the origin of the tumor cells suggested by "neurofibroma" or schwannoma. The tumor showed cells having large, vesicular, elongated nuclei of oval or spindle shape. These were arranged in large concentric whorls with rather abundant mucoid intercellular substance. The cells were rather uniform in appearance throughout the section. In some regions small concentric whorls were seen, but for the most part the tumor cells were rather loosely arranged, showing a slight tendency toward palisading of the nuclei. There were no areas of increased density, increase in mitotic figures or invasion of the capsule to indicate that the tumor might be malignant.

Gaston<sup>467</sup> describes in detail a bone block for paralytic drop foot, which incorporates removal of the distal attachment of the achilles tendon with an attached piece of bone. Care is taken

to avoid disturbing tissue lying posterior to ankle joint and at the lower end of the tibia so as to avoid postoperative proliferation of bone.

[ED. NOTE.—We feel that the bone block goes under the tibia instead of posterior to it is more satisfactory. The procedure is equally simple and more durable.]

Greene<sup>468</sup> describes a refrigerator that was developed in collaboration with R. J. Simpson of the International Refrigerator Company. They designed an apparatus in which the extremity can be put through an opening in the cabinet in a compartment in which the temperature can be controlled.

[ED. NOTE.—He has had no opportunity for clinical application, but it makes sense to have that an apparatus which will control temperature might be of some aid when it is necessary to obtain lesser degrees of cold.]

Causton<sup>469</sup> describes a technic for taking roentgenogram of the sesamoid bones in the region of the first metatarsophalangeal joint. With the patient lying in a prone position the great toe rests in a position of hyperextension the film is supported under the first metatarsophalangeal joint and the tube adjusted so that the central ray, which is vertical, passes between the sesamoid bones. A further view is obtained with the patient on his uninjured side. The film is placed under the distal portion of the first metatarsal bone and is allowed to conform to the natural slope of the medial aspect of the foot. The tube is then adjusted so that the central ray passes through the medial sesamoid bone and makes an angle of 40 degrees with the film.

Gottlieb<sup>470</sup> believes that a definite clinical entity is brought about by a diseased sesamoid bone. He describes 11 cases, in 10 of which the patients were women who all wore high arched shoes, with excessive weight on the first joint. The symptoms were usually unilateral. He does not believe that the bone was fractured. The cause of the disease is repeated trauma. He recommends conservative treatment first which consists of resting, immobilization and relief of weight bearing on the affected area and the injection of procaine hydrochloride and other physical therapeutic measures. Only when these have failed should removal of the affected bone be carried out.

465. McElvenny, R. T.: The Etiology and Surgical Treatment of Intractable Pain About the Fourth Metatarsophalangeal Joint (Morton's Toe), *J. Bone & Joint Surg.* 25:675-679 (July) 1943.

466. Hauser, E. D. W.: Neurofibroma (Neurinoma) of Foot, *J. A. M. A.* 121:1217-1219 (April 10) 1943.

467. Gaston, J. H.: Modified Bone Block for Paralytic Foot Drop, *South. M. J.* 36:336-338 (May) 1943.

468. Greene, R.: Cold in Treatment of Damage Due to Cold, *Lancet* 2:695-697 (Dec. 12) 1942.

469. Causton, J.: Projection of Sesamoid Bones in Region of First Metatarso-Phalangeal Joint, *Radiotherapy* 9:39 (May) 1943.

470. Gottlieb, A.: Diseased Tibial Sesamoid of Big Toe Joint, *West. J. Surg.* 51:193-195 (May) 1943.

Cane<sup>471</sup> reports a case of neglected congenital equinovarus, in which treatment included removal of the talus in addition to lengthening of a tendon.

[ED. NOTE.—This method did improve the situation in the case which he reports.]

Smith<sup>472</sup> uses the Keller-Brandes type of operation for hallux valgus. The technic consists in a partial phalangectomy of the proximal portion of the first phalanx of the great toe. It is a relatively simple procedure and allows early return to function. It does give good results in hallux rigidus.

[ED. NOTE.—We feel that this is a good procedure for hallux rigidus, but on hallux valgus and the concomitant deformity it has little influence.]

Lewis<sup>473</sup> reports 8 cases of the less common lesions of the astragalus, to call attention to the wide variety of pathologic changes occurring in this bone. His report includes the following types of disease: tuberculosis, staphylococcal osteomyelitis, osteochondritis dissecans, aseptic necrosis, osteochondroma, osteitis fibrosa cystica, endromatous giant cell tumor and metastatic sarcoma.

Cobey<sup>474</sup> reports 3 cases of osteochondritis of the dorsal articular surface of the astragalus. He recommends roentgen examination for severe lesions, keeping in mind the possibility of this condition. The presence of a loose body in this joint leads to arthritic changes, and early removal of the loose fragment is recommended.

Lipscomb and Ghormley<sup>475</sup> say where possible fractures of the astragalus should be reduced by closed manipulative procedures, followed by fixation by means of a plaster of paris cast. No weight bearing should be allowed for eight to ten weeks. When it is not possible to get a good reduction by manipulative measures they recommend an open operation. They use a lateral incision along the ankle at the level of the subastragaloid joint. The peroneal tendon can be displaced or if necessary divided and repaired later. After reduction of the fracture

the position can be held by means of screws. They prefer vitallium screws. When the damage is severe and the displacement great, astraglectomy is done. In old cases in which there is a great deal of pain arthrodesis is sometimes necessary. He feels that the pain is often due not to the failure of union but to the arthritic changes that occur.

McLaughlin<sup>476</sup> states that in the majority of the reported cases rupture of the achilles tendon is due to strenuous physical exercises. For treatment he advises operative repair. The tendon usually tears at the junction of the tendon and the muscular portion of the gastrocnemius muscle. He uses silk sutures for repair and maintains fixation in the original cast for about six weeks and then brings the foot to a right angle to the leg two weeks following surgical operation, with return to full activity in from nine to twelve weeks.

[ED. NOTE.—In our experience rupture of the achilles tendon is not such an infrequent occurrence, but many of them are partial tears that can be treated effectively by conservative measures. The severe ones should be repaired.]

Paulson<sup>477</sup> encountered a severe injury of the navicular bone of the foot, which was giving symptoms. He removed the navicular bone entirely and obtained a good functional result.

O'Donoghue and Sell<sup>478</sup> report a case of congenital talonavicular synostosis. It is a rare condition, which was described originally in 1879 by Anderson, who reported a bilateral condition. In the case reported here the synostosis was bilaterally symmetric.

Daseler and Anson<sup>479</sup> give a report on the plantaris muscle, based on a review and a study of 750 consecutive specimens. They regard the plantaris muscle and tendon as the vestigial remains of a primitive flexor muscle of the toes, which, originally continuous with the plantar aponeurosis, later was rendered discontinuous through intermediate attachment to the calcaneum. The plantaris muscle and its tendon are subject to considerable variation in both

471. Cane, L. H.: Congenital Talipes Equinovarus corrected by Talcotomy, *East African M. J.* 20:2-4 (Jan.) 1943.

472. Smith, P. E.: Hallux Valgus: Consideration of Keller-Brandes Operation, *Mississippi Doctor* 20:445-0 (March) 1943.

473. Lewis, R. W.: Less Common Lesions of the Astragalus, *Ann. Surg.* 116:891-897 (Dec.) 1942.

474. Cobey, M. C.: Osteochondritis Dissecans of the Astragalus, *Mil. Surgeon* 93:184-186 (Aug.) 1943.

475. Lipscomb, P. R., and Ghormley, R. K.: Old and New Fracture-Dislocations of the Astragalus, *S. Clin. North America* 23:995-1011 (Aug.) 1943.

476. McLaughlin, C. W., Jr.: Complete Rupture of Tendo-Achilles: Report of Case, *U. S. Nav. M. Bull.* 41:1388-1391 (Sept.) 1943.

477. Paulson, E. C.: Foot Functions Following Loss of the Tarsal Navicular, *Minnesota Med.* 26:545-547 (June) 1943.

478. O'Donoghue, D. H., and Sell, L. S.: Congenital Talonavicular Synostosis: A Case Report of a Rare Anomaly, *J. Bone & Joint Surg.* 25:925-927 (Oct.) 1943.

479. Daseler, E. H., and Anson, B. J.: Plantaris Muscle: Anatomical Study of 750 Specimens, *J. Bone & Joint Surg.* 25:822-827 (Oct.) 1943.

the point of origin and the point of insertion. In an examination of 150 lower extremities, the authors have encountered four types of insertion of the tendon. Of 750 consecutive lower extremities examined by the authors the plantaris muscle was absent in 50 (6.67 per cent). In one third of the specimens in which the muscle was missing, the absence was bilateral. The surgical utilization of the plantaris tendon is particularly indicated as a desirable substitute for the fascia lata in hernial repair, transplantation of tendons and repair of ligaments.

[ED. NOTE.—Another significance of the plantar muscle is that in lengthening the achil tendon it must be divided because it is a separate muscle.]

Albert and Mitchell<sup>480</sup> report 3 cases of Volkmann's ischemia of the leg. They recommend early recognition of the condition and early surgical intervention. The harmful results of a skin-tight plaster cast are stressed.

480. Albert, M., and Mitchell, W. R. D.: Volkmann Ischemia of Leg, *Lancet* 1:519-522 (April 24) 1943.

### XIII. TUBERCULOSIS OF BONES AND JOINTS

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In a study by Tytler and Lapp,<sup>481</sup> prominin (sodium salt of p,p'-diamino-diphenylsulfone-N-N'-didextrose sulfonate) in a concentration of 5 per cent in a medium of tragacanth jelly was repeatedly injected, after aspiration of pus, into tuberculous abscesses and sinus tracts of 10 patients. The abscesses treated were in the following regions: 4 in the lumbar region, 2 in the groin, 1 in the low dorsal region, 1 in the right ilium region, 1 in the right ilium and 1 in the neck. While the results were somewhat irregular, the clinical opinion was formed that improvement in all patients was greater or more rapid than would have been expected with orthodox methods. It is thought that these results justify a more extensive trial of the drug by local application to suitable lesions and possibly by injection into more deep-seated lesions.

Callomon<sup>482</sup> found that experimental tuberculosis of guinea pigs was apparently somewhat inhibited by administration of prominin, 4 (alpha-pyridil-N-sulfonamido)-phenyl-2-azo-8-amino-1-naphthol-5, 7 disulfonic acid and disodium formaldehyde sulfoxylate diaminodiphenylsulfone. Results with the first and third of these compounds were considered as encouraging for further investigation. Sulfanilamide, sulfapyridine, sulfathiazole and sulfathiazoline showed no appreciable effect under the same conditions of experimentation.

Feldman and Hinshaw<sup>483</sup> studied the tuberculotherapeutic efficiency of two compounds of

the sulfonamide series and four of the sulfone series in guinea pigs which six weeks previously had been inoculated subcutaneously with human tubercle bacilli. Drugs were administered for one hundred and twenty-eight days, after which time all the control animals were dead, and the experiment was terminated. The lowest mortality rate, 19 per cent, was in the prominin-treated group; that in the group treated with sulfadiazine and another sulfonamide compound was 71 per cent. The results indicated definitely the superiority of the derivatives of 4, 4'-diaminodiphenylsulfone over compounds containing a sulfonamide nucleus.

Steinbach and Duca<sup>484</sup> found prominin in vitro to be bacteriostatic for every acid-fast bacillus tested, including saprophytes and piscine, avian, human and bovine tubercle bacilli. Prominin given to guinea pigs subcutaneously three times daily starting with the day of experimental infection exerted a retarding effect on the course of the tuberculosis. Although prominin influences the disease in the experimental animal to a greater extent than any other chemotherapeutic agent which the authors have tested, it is extremely toxic. Results were promising in 6 of 11 cases of advanced human pulmonary tuberculosis in which prominin was administered, but a large series of cases will be required before conclusions can be drawn as to the efficacy of the drug in man.

McClintock and Goodale<sup>485</sup> report that in vitro a 12 mg. per hundred cubic centimeter solution of the potassium salt of the sulfapyridine-choleate complex appears to inactivate tubercle

481. Tytler, W. H., and Lapp, A. D.: Treatment of Superficial Tuberculous Lesions by Local Application of Prominin, *Brit. M. J.* 2:748-749 (Dec. 26) 1942.

482. Callomon, F. F. T.: New Derivatives of Diaminodiphenylsulfone: Their Therapeutic Effect in Experimental Tuberculosis of Guinea Pigs, *Am. Rev. Tuberc.* 47:97-106 (Jan.) 1943.

483. Feldman, W. H., and Hinshaw, H. C.: Comparative Effects of Six Compounds Administered with Therapeutic Intent to Tuberculous Guinea Pigs, *Am. J. Clin. Path.* 13:144-147 (March) 1943.

484. Steinbach, M. M., and Duca, C. J.: Chemotherapy in Tuberculosis, *Tuberculo*logy 6:93-95 (May) 1943.

485. McClintock, L. A., and Goodale, R. H.: Use of Choleate Principle in Treatment of Tuberculosis, *U. S. Nav. M. Bull.* 41:708-713 (May) 1943.

bacilli after eight days' incubation. The ability of the drug to inhibit the growth of tubercle bacilli in vivo has been borne out by experiments on animals. Of 160 treated animals (guinea pigs), 31 died as a result of combined action of the drug and coccidiosis. Of the remaining 129 animals, 2 showed tuberculosis grossly and microscopically. All of the others gave negative reactions. Most of the control animals died within fifty days of extensive tuberculosis. It is felt that the complex exerts an inhibitory effect on the tubercle bacillus in vitro and in vivo.

Medlar and Sasano<sup>486</sup> administered promin to guinea pigs for five months; beginning ten days after virulent tubercle bacilli had been injected subcutaneously. The last survivor was killed eighteen months after therapy was stopped. Ninety-two per cent of the animals in the promin-treated group, in contrast with 36 per cent in the untreated control group, were alive when therapy was discontinued. In the promin-treated group 24 per cent died of uncomplicated generalized tuberculosis; 28 per cent exhibited small localized tuberculous foci in the spleen, liver or lungs, and 48 per cent showed no macroscopic evidence of visceral tuberculosis, though in 77 per cent of these cultures tubercle bacilli were obtained from the spleen. Promin, therefore, retarded decidedly but did not eradicate the tuberculous infection. Results to be expected from any chemotherapeutic method for tuberculosis must be tempered by knowledge that the disease is chronic, that the repair of damage to tissue is slow and that the majority of tuberculous patients in sanatoriums have only a limited resistance to the infection. The extermination of the infecting agent with promin therapy should not be anticipated, but these favorable experimental results warrant further chemotherapeutic studies to reveal compounds that may be even better than promin.

486. Medlar, E. M., and Sasano, K. T.: Promin in Experimental Tuberculosis in Guinea Pig, *Am. Rev. Tuberc.* 47:618-624 (June) 1943.

[ED NOTE.—These experiments give some promise that the effort to discover a drug which will have an influence on the tubercle bacillus comparable to that of the sulfonamide compounds on many of the pyogenic organisms may be successful. Thus far the therapeutic value of promin seems far from being established, however.]

Perlman and Freiberg<sup>487</sup> describe 5 cases of tuberculosis of the lumbar portion of the spine in adults in which there was an osseous bridge between two of the bodies. In 4 this was complete and in the fifth partial. The diagnosis was proved in 4 cases by demonstration of tubercle bacilli or by positive results of guinea pig inoculation with the pus from an abscess. In the fifth case the diagnosis was presumptive from the finding of tubercle bacilli in multiple cutaneous lesions.

[ED. NOTE.—These findings are of importance chiefly from the standpoint of diagnosis. The bridging of the bodies which took place in these cases probably was not extensive enough to be relied on for fixation. It has been pointed out that a mild type of osteomyelitis frequently involves the spine and that one of the characteristics which differentiates such a pyogenic infection of the vertebrae from tuberculosis is early bony union of the bodies. This condition practically always follows a pyogenic infection elsewhere and is associated with a greater degree of pain. The differential diagnosis between tuberculosis and a pyogenic infection in a lesion associated with bridging of the bodies might be difficult in some cases but usually can be made with a reasonable degree of certainty by laboratory tests and on the basis of the existence of associated lesions. It is important to differentiate the two, because fusion is indicated for tuberculosis and not only is futile for pyogenic osteomyelitis but may be detrimental.]

487. Perlman, R., and Freiberg, J. A.: The Bridging of the Vertebral Bodies in Tuberculosis of the Spine, *J. Bone & Joint Surg.* 25:340-350 (April) 1943.

#### XIV. CHRONIC ARTHRITIS

PREPARED BY LORING T. SWAIM, M.D., BOSTON

*General Considerations.*—Because of the war there have been fewer articles and possibly less original research work on arthritis reported in 1943 than in previous years. Nevertheless there are certain articles of interest. Burbank<sup>488</sup> gives

an interesting review of arthritis through the ages, stating that evidence of arthritis was present in the fossilized remains at the beginning of the reptilian age, when vertebrates started to inhabit the globe; the first skeletal proof of arthritic changes was found to date back to this period. He also draws attention to the fact that many of the great men of history had

488. Burbank, R.: Arthritis Through the Ages, *Tri-State M. J.* 15:2903-2911 (March) 1943.

arthritis; among them were Julius Caesar, Alexander Farnese, Frederick the Great and others.

Seltzer,<sup>489</sup> a research fellow in physical anthropology at Harvard, reports on a series of almost 400 patients from the Robert Breck Brigham Hospital after careful anthropometric measurements. He decides that patients with rheumatoid arthritis are remarkably different in bodily physique from those with degenerative disease of the joints.

The physical differences between the two groups were often of such magnitude that the level of statistical significance was reached in the case of a very large number of measures. This occurred in spite of the small size of the series involved. . . . From the profusion of detailed differentiae the degenerative joint disease group may be roughly described as being bigger, heavier, and more lateral in body build than the rheumatoid arthritics. . . . Although it is true that the rheumatoid arthritics are more linear in body build than the degenerative joint disease group, the results of this investigation do not agree with the impressions of many clinicians who stress the linearity and distinctiveness of the rheumatoids. . . . The degenerative joint disease group exhibits greater anthropological distinctiveness and homogeneity than the rheumatoids.

He believes that the physical characteristics of patients with degenerative arthritis have some bearing on the type of arthritis. He finds the same true for men and for women.

Of general interest also is the study of Stone<sup>490</sup> in which 22 cases of rheumatoid arthritis were studied from a neurologic and an endocrinologic aspect. He found that with vitamin E (wheat germ oil) and fever therapy improvement occurred in 17 of 22 cases.

Pain is a problem of great significance, according to Smyth and Freyberg,<sup>491</sup> and needs control by rest, splints, drugs, roentgen treatment and physical means.

Treusch and Krusen<sup>492</sup> found, in a study of 218 patients with all types of arthritis for whom home physical therapy was recommended, that

489. Seltzer, C. C.: *Anthropometry and Arthritis: Differences Between Rheumatoid and Degenerative Joint Diseases; Females, Medicine* 22:189-203 (May) 1943; *Anthropometry and Arthritis: Differences Between Rheumatoid and Degenerative Joint Disease; Males, ibid.* 22:163-188 (May) 1943.

490. Stone, S.: *Neurological and Endocrine Aspects of Atrophic Arthritis (Deformans): Report on Use of Vitamin E and Artificial Fever, J. Nerv. & Ment. Dis.* 97:638-655 (June) 1943.

491. Smyth, C. J., and Freyberg, R.: *Significance and Management of Joint Pain, J. Michigan M. Soc.* 42: 818-822 (Oct.) 1943.

492. Treusch, J. V., and Krusen, F. H.: *Physical Therapy Applied at Home for Arthritis: Follow-Up Study with Supplementary Summary of Sedimentation Rate of Erythrocytes in 229 Cases of Arthritis, Arch. Int. Med.* 72:231-238 (Aug.) 1943.

92.7 per cent of the patients carried out the treatment. The number of patients who continue treatment depended on the number of individual lessons given. [Ed. NOTE.—This is of interest from the point of view of a planned schedule.]

Banghart<sup>493</sup> believes that he can control pain by the use of bee venom, but he finds only one preparation of real value: *apis mellifica*, which is distributed by John A. Borneman and Sons. Of 16 cases he found the improvement marked in 9, moderate in 5 and poor in 2. In 4 of the 16 cases a second course of injections was required. There were no good results in the 4 cases of Marie-Strümpell disease. As with many forms of treatment, the results seem to depend on the type of material used.

Hartung<sup>494</sup> believes:

A simultaneously applied program of constitutional rehabilitation, gold salts, whole blood transfusions, and prevention and treatment of deformities will produce satisfactory results in over half of the patients with rheumatoid arthritis.

Ludwig, Short and Bauer<sup>495</sup> observed an increase of protein in the cerebrospinal fluid in 101 arthritic patients. Forty-two had spondylitis, and 59 had peripheral arthritis. Fifteen of the 16 patients with increased protein in the cerebrospinal fluid had either spondylitis or symptoms suggesting spinal involvement. Apparently the increased protein content depended on inflammatory activity about the spine.

Attention is called to the diagnostic difficulties presented by patients with rheumatoid spondylitis and increased cerebrospinal-fluid protein, with particular reference to their differentiation from cases with ruptured intervertebral disks.

Fingerman and Andrus<sup>496</sup> found lesions of rheumatic heart in 31 per cent (or 19) of 61 autopsies. In 6 of the 19 there was evidence of congestive heart failure, with chronic passive congestion of the liver; amyloidosis of one or several organs was observed in 13 and glomerulitis in 8. These findings agree with those of Bayles and others who have reported the prevalence of cardiac conditions with rheumatoid arthritis.

493. Banghart, H. E.: *Bee Venom for Relief of Arthritic and Rheumatic Pain, Hahnemann. Monthly* 78: 19-22 (Jan.) 1943.

494. Hartung, E. F.: *Treatment of Rheumatoid Arthritis Including Gold Salts Therapy, Bull. New York Acad. Med.* 19:693-703 (Oct.) 1943.

495. Ludwig, A. O.; Short, C. L., and Bauer, W.: *Rheumatoid Arthritis as Cause of Increased Cerebrospinal Fluid Protein: Study of 101 Patients, New England J. Med.* 228:306-310 (March 11) 1943.

496. Fingerman, D. L., and Andrus, F. C.: *Visceral Lesions Associated with Rheumatoid Arthritis, Ann. Rheumat. Dis.* 3:168-181 (May) 1943.

Fraser<sup>497</sup> reports 61 cases of rheumatoid arthritis in which he tried to follow Cecil's technic for making blood cultures. He recovered no streptococci. He did recover diphtheroid bacilli in 3 cases. He draws attention to the fact that bacteremia due to trauma or treatment such as massage may occur and cause a blood culture to elicit a positive reaction.

[ED. NOTE.—In the Manual of Occupational Therapy<sup>498</sup> an excellent article has been written on occupational therapy for arthritis. It is well worth studying. It takes up the various main points: (1) rest through diversion; (2) constructive exercises; (3) prevention of neurosis and helplessness, and (4) importance of emotional outlet and readjustment for the future. The occupation should provide exercise for the joints and muscles.

Another primer has been written by the Committee of the American Rheumatism Association and has been published in *The Journal of the American Medical Association*.<sup>499</sup> This is an excellent review of the present knowledge of arthritis. It can be secured from *The Journal of the American Medical Association*. It carries the names of authorities in the United States.]

Bauer and Engleman<sup>500</sup> draw attention to a syndrome of unknown cause which is characterized by urethritis, conjunctivitis and arthritis. It is called Reiter's disease. They hope that clinicians and bacteriologists will watch for this syndrome.

From a nutritional angle, Bayles, Richardson and Hall<sup>501</sup> report 31 cases in which the pre-rheumatic diet was studied. They come to the conclusion that it is not different from the usual American diet and that if a food factor contributes to the onset of rheumatoid arthritis

their studies suggest that it may be caused by the increased total requirement of the patient rather than a deficiency diet. They feel that because of the frequent deficiency states found the disease itself may increase the requirements of food, especially of the vitamin B complex.

*Gout*.—This disease is still being found and studied. Bartels,<sup>502</sup> of the Lahey Clinic, reports treatment with a diet low in purine and fat and high in carbohydrate and cinchophen.

On this plan of treatment seven minor attacks of gout occurred, as compared with 84 major attacks during a comparative period before treatment. This plan of treatment secured the desired results of reducing the blood uric acid level and reducing the number and severity of further attacks of gout. Even patients in the phase of chronic gouty arthritis responded to this plan of treatment.

They believe that cinchophen is not so dangerous when given with carbohydrate and protein.

Linton and Talbott<sup>503</sup> report the excellent results of removal of tophaceous deposits in 11 patients, with relief of pain and restoration of function. They describe the operative procedures and point out the necessity of good medical care. They stress the resultant "improved cosmetic appearance and in many instances permanent eradication of tophaceous deposits" and "adequate preoperative and post-operative treatment of the patient with colchicine."

Neuwirth<sup>504</sup> writes to the contrary. He emphasizes the dangers and later effects of using cinchophen. He points out that the cause of hyperuricemia, of retention of urates and of precipitation of sodium urate is not yet known.

Research still goes on, however. Oppenheimer and Kunkel,<sup>505</sup> in the *Bulletin of the Johns Hopkins Hospital*, report on the injection of a solution of the enzyme uricase, extracted from pig's liver. This was given intramuscularly after being made bacteria free by filtration. The extract remains active about two months when frozen and stored at —28 C.

Single injections of this purified uricase extract can produce a sharp lowering of the plasma uric acid of "gouty" chickens. . . . Continued daily administra-

497. Fraser, T. N.: Blood Cultures in Rheumatoid Arthritis: Historical and Personal Observations, *Ann. Rheumat. Dis.* **3**:181-190 (May) 1943.

498. Occupational Therapy: Manual Prepared by Council of Physical Therapy of American Medical Association, Committee of American Occupational Therapy Association and Subcommittee on Physical Therapy and Committee on Information of Division of Medical Sciences of National Research Council, *War Med.* **3**: 635-656 (June) 1943.

499. Jordan, E. P., and others: Primer on Arthritis Prepared by Committee of American Rheumatism Association, *Rev. Assoc. méd. argent.* **56**:532-542 (Sept. 15-30) 1942; *J. A. M. A.* **119**:1089-1104 (Aug. 1) 1942.

500. Bauer, W., and Engleman, E. P.: Syndrome of Unknown Etiology Characterized by Urethritis, Conjunctivitis, and Arthritis (So-Called Reiter's Disease), *Tr. A. Am. Physicians* **57**:307-313, 1942.

501. Bayles, T. B.; Richardson, H., and Hall, F. C.: Nutritional Background of Patients with Rheumatoid Arthritis, *New England J. Med.* **229**:319-324 (Aug. 19) 1943.

502. Bartels, E. C.: Successful Treatment of Gout, *Ann. Int. Med.* **18**:21-28 (Jan.) 1943.

503. Linton, R. R., and Talbott, J. H.: Surgical Treatment of Tophaceous Gout, *Ann. Surg.* **117**:161-182 (Feb.) 1943.

504. Neuwirth, E.: Milestones in Diagnosis and Treatment of Gout, *Arch. Int. Med.* **72**:377-387 (Sept.) 1943.

505. Oppenheimer, E. H., and Kunkel, H. G.: Further Observations on Lowering of Blood Uric Acid by Uricase Injections, *Bull. Johns Hopkins Hosp.* **73**:40-53 (July) 1943.



tion of uricase to "gouty" chickens, made "gouty" by a high protein diet, causes a continued lowering of their plasma uric acid, although they are maintained on the same "gout"-producing diet.

It also "prevents the plasma uric acid level from rising to a 'gouty' level in chickens simultaneously fed a 'gout'-producing diet." [Ed. NOTE.—This may be an important finding in the control and prevention of gout.]

*Vitamin D.*—The controversy still continues as to the use of massive doses of vitamin D for arthritis. Snyder, Squires, Forster and Rudd<sup>506</sup> still claim that results can be secured only by using ergosterol electrically activated prepared by the Whittier process, namely (ertron). They emphasize the fact that ultraviolet-irradiated ergosterol gave bad results in 80 per cent of their cases. It was not tolerated. They gave it to 30 patients for twelve months; 77 per cent were not benefited, 57 per cent refused to continue taking it and 5 only, or 17 per cent, became better. These were different from their results with electrically activated ergosterol. They also report a group of cases<sup>507</sup> in which they used intramuscular injections of electrically activated ergosterol and as much as 1,000,000 1,500,000 units proved effective. There were no untoward local or systemic symptoms, and they prevented gastric irritation by using the intramuscular route. They believe that it is perfectly safe, whether given orally or intramuscularly.

[ED. NOTE (L. D. B.).—Ertron is a proprietary preparation which has not been accepted by the Council on Pharmacy and Chemistry of the American Medical Association. The claims of its advantages have been challenged. Before he describes the preparation the physician should read some of these challenging reports and should familiarize himself with the toxic manifestations.<sup>507a</sup>]

506. Snyder, R. G.; Squires, W. H., and Forster, J. V.: Six-Year Study of Arthritis Therapy with Special Reference to Pharmacology, Toxicology and Therapeutics, *Indust. Med.* 12:291-297 (May) 1943.

507. Snyder, R. G.; Squires, W. H.; Forster, J. W., and Rudd, E.: Therapeutic Value of Electrically Activated Ergosterol When Administered Intramuscularly: Preliminary Report, *Indust. Med.* 12:663-668 (Oct.) 1943.

507a. Condol and Ertron Not Acceptable for N. N. R., report of the Council on Pharmacy and Chemistry, *A. M. A.* 109:132-133 (July 10) 1937. Freyberg, A. H.: Treatment of Arthritis with Vitamin and Endocrine Preparations: Emphasis of Their Limited Value, *ibid.* 119:1165-1171 (Aug. 8) 1942. Freeman, J.: Irradiated Ergosterol Poisoning, correspondence, *ibid.* 119:968 (July 18) 1942. Boots, R. H., and Sachs, R.: Hope [False] for the Victims of Arthritis, correspondence, *ibid.* 123:857 (Nov. 27) 1943.

Klassen and Curtis<sup>508</sup> report the effect of massive doses of vitamin D on calcium phosphorus metabolism as negligible. "There was no primary disturbance in the calcium phosphorus metabolism in the patients with atrophic spondylitis or with degenerative arthritis of the spine."

*Gold Therapy.*—More evidence is constantly appearing as to the beneficial effect of gold therapy on arthritis, as it has been more extensively used. Graham and Fletcher<sup>509</sup> report on 100 patients. Ninety-five received up to 1 Gm. of a gold compound. Of these 67 per cent were improved and 20 per cent obtained moderate improvement. Fifty-four of the 100 had a mild toxic temporary reaction; 4 showed exfoliative dermatitis. They believe the gold is valuable, but the good results did not depend on drug therapy alone. "There is evidence that general medical care and protection contribute to favourable progress and lessen likelihood of relapse." They emphasize the fact that there are serious dangers.

Price and Leichtentritt<sup>510</sup> state:

Aurotherapy should be limited to rheumatoid arthritis and is most effective in the early stages of the disease. It is also frequently effective in relieving pain and stiffness in advanced cases and is therefore worthy of a trial in these patients. . . . Gold is a toxic drug and should be used only by those having experience with it.

Winkler<sup>511</sup> agrees with them but adds that the results in cases of Marie-Strümpell disease or spondylitis are not especially outstanding since in most of these cases severe disturbance in the joints and ankylosis are present before treatment is instituted. He believes the gold therapy may be resumed after the toxic symptom subsides. He also notes: "Longer periods of observation are required to determine the permanency of the results."

Cohen and Dubbs<sup>512</sup> review a series of 122 patients who received a total of one hundred and seventy-six courses of intramuscular injections of 1.24 Gm. of aurothiodextrose. Thirty-

508. Klassen, K. P., and Curtis, G. M.: Effect of Massive Doses of Vitamin D on Calcium and Phosphorus Metabolism: Observations on Patients with Atrophic Spondylitis and with Degenerative Arthritis of Spine, *Arch. Int. Med.* 71:78-94 (Jan.) 1943.

509. Graham, J. W., and Fletcher, A. A.: Gold Therapy in Rheumatoid Arthritis, *Canad. M. A. J.* 49:483-487 (Dec.) 1943.

510. Price, A. E., and Leichtentritt, B.: Gold Therapy in Rheumatoid Arthritis, *Ann. Int. Med.* 19:70-80 (July) 1943.

511. Winkler, H.: Gold Therapy of Rheumatoid Arthritis, *North Carolina M. J.* 4:161-163 (May) 1943.

512. Cohen, A., and Dubbs, A. W.: Treatment of Rheumatoid Arthritis with Gold, *New England J. Med.* 229:773-776 (Nov. 18) 1943.

six per cent were much improved, 9 per cent showed no change and 4 per cent were worse. They emphasize the fact that more than one course of treatment is necessary in many cases. They believe that the reduction in toxic reactions was due to the use of fruit juice or vitamin C. They also used extreme caution and gave liver, vitamin B and small doses of the gold compound, 50 mg. They believe that these precautions were the reason for the reduction of untoward reactions.

Freyberg, Block and Levey<sup>513</sup> again report extremely interesting studies on metabolism of gold used in the treatment of rheumatoid arthritis. They found that soluble gold salts were excreted chiefly in the urine while colloidal gold salts were excreted more in the feces.

These complete excretion studies show that gold is retained in large amounts during the period of treatment; the retention ranged from 77 to 88 per cent with the crystalline salts, and often more than 99 per cent with colloidal gold sulphide.

They found that the content of gold in the plasma and the content excreted when the soluble gold sodium thiosulfate was used were the same, whether it was given intravenously or intramuscularly.

Block, Buchanan and Freyberg<sup>514</sup> also report that insoluble gold salts are slowly absorbed. Larger amounts were found in liver and kidney than in other tissues, and the soluble gold salts were excreted by the kidneys and the insoluble by the intestines. [ED. NOTE.—These studies are of inestimable value in increasing knowledge of gold therapy.]

Another valuable contribution is that of Bayles and Hall,<sup>515</sup> in which they demonstrate a way of recording the effect of gold therapy on rheumatoid arthritis. Charts are shown which clearly illustrate the value of tabulating results. This article should be read.

*Surgical Treatment.*—There is only one article on surgical treatment, by Smith-Petersen,

Aufranc and Larson.<sup>516</sup> They suggest that in order to relieve pain surgical operation should be done early before it is too late. Acromioplasty, excision of the head of the radius and excision of the distal end of the ulna are the operative procedures suggested. They point out that early surgical treatment should be done before destruction of the joints is too far advanced to allow maximum benefit from the operation.

*Psychologic Aspects.*—Emotional disturbances are found in many instances. Swaim<sup>517</sup> draws attention to the fact that they are found in cases of arthritis. The factors of emotional outlets can no longer be avoided. Anger and fear have profound physiologic effects, and investigations in the last ten years show that anxiety and resentment are the two most constant emotional reactions found in arthritic patients. These suggest that maladjusted human relationships are a fundamental problem. He points out that application of spiritual laws will help adjust these conflicts, by "feeding a starved spirit." He believes that physicians should pioneer again in this field of medicine.

*Food Allergy.*—Food allergy as a possible factor in subacute recurrent arthritis is discussed by Vaughan<sup>518</sup> in a study of a consecutive series of 1,000 adults. Twenty-seven had recurrent subacute involvement of various joints, and for these the causative foods were discovered and attacks prevented by their avoidance. Thirty-two foods were incriminated. He mentions Kahlmeter's 54 cases in which the condition was attributed to allergy, among approximately 5,000 rheumatic patients, Solis-Cohen's 27 cases observed in twenty years in which allergy may have played a part and Hench and Rosenberg's 34 cases of recurrent or palindromic rheumatism. He states:

Although food allergy has not been proved to play a part in the majority of arthritics, there appears to be a small group in whom intermittent hydroarthrosis involving large joints or multiple small joints (with a picture of recurrent subacute rheumatoid arthritis) may be caused by food allergens.

513. Freyberg, R. H.; Block, W. D., and Levey, S.: Metabolism, Toxicity and Manner of Action of Gold Compounds Used in Treatment of Arthritis: Complete Excretion Studies and Comparison of Intravenous and Intramuscular Administration of Some Gold Salts, *Ann. Rheumat. Dis.* 3:77-89 (Dec.) 1942.

514. Block, W. D.; Buchanan, O. H., and Freyberg, R. H.: Metabolism, Toxicity and Manner of Action of Gold Compounds Used in Treatment of Arthritis: Studies of Absorption, Distribution and Excretion of Gold Following Intramuscular Injection of Gold Thioglucose and Gold Calcium Thiomalate, *J. Pharmacol. & Exper. Therap.* 76:355-357 (Dec.) 1942.

515. Bayles, T. B., and Hall, M. G.: Yardstick for Rheumatoid Arthritis Applied to Patients Receiving Gold Salt Therapy, *New England J. Med.* 228:418-421 (April 1) 1943.

516. Smith-Petersen, M. N.; Aufranc, O. E., and Larson, C. B.: Useful Surgical Procedures for Rheumatoid Arthritis Involving Joints of Upper Extremity, *Arch. Surg.* 46:764-770 (May) 1943.

517. Swaim, L. T.: President's Address (American Rheumatism Association), *Ann. Int. Med.* 19:118-121 (July) 1943.

518. Vaughan, W. T.: Food Allergy as a Possible Factor in Subacute Recurrent Arthritis, *Ann. Int. Med.* 19:122-124 (July) 1943.

*Myalgia*.—Good<sup>519</sup> reports 500 cases of myalgia in the British army. Myalgia is a frequent disease localized in certain anatomic parts of one or more muscles—"myalgic spots."

Myalgia is present in and responsible for the vast majority (according to statistics 95 per cent) of patients suffering from rheumatism; it is not rarely associated

519. Good, M.: Five Hundred Cases of Myalgia in British Army, *Ann. Rheumat. Dis.* 3:118-138 (Dec.) 1942.

with rheumatoid arthritis, osteoarthritis, and common with rheumatic fever. . . . It is often of unknown origin—idiopathic myalgia—and mimics visceral a nervous diseases (heart pain, neuralgia or neuritis sciatica, syndrome of painful feet, etc.)

He describes the myalgic spots—the characteristic feature of myalgia of the neck, shoulder, arm, back, lumbar region, hip and leg. He recommends injection of procaine hydrochlorid which relieves pain in a dramatic way and leads to rapid cure.

## XV. FRACTURE DEFORMITIES

PREPARED BY EUGENE M. REGEN, M.D., NASHVILLE, TENN.; R. BEVERLY RANEY, M.D., DURHAM, N. C.; GLEN BARBER, M.D., CLEVELAND, AND PAUL HARMON, M.D., SAYRE, PA.

The literature for 1943 includes a number of excellent articles on delayed union of fractures and on nonunion, while little emphasis has been placed on malunion. In these articles, all of which are written from a clinical standpoint, attention has been directed about equally to study of the causes of delayed union and nonunion and to exposition of grafting technics, with statistical analyses of the results.

*Clinical Studies of Delayed Union and Nonunion*.—In a comprehensive article, which merits careful study for full understanding and appreciation, Watson-Jones and Coltart<sup>520</sup> have analyzed a series of 804 fractures of the shaft of the tibia and femur. They state that the test of success in the treatment of a fracture is the quality of the end result rather than the time taken in achieving it. Time is not saved when recovery is accelerated at the cost of permanent disability; a disabled man loses time every day of his life. The period of disability for any fracture is important; of the many factors which influence this period, the most constant is the time taken for the fracture to unite. As a broad generalization, it may be estimated that the duration of total disability is half as long again as the time taken for union of the fracture. The authors disagree with the frequently expressed opinion that fractures of the tibia and femur now unite more slowly than they did several decades ago. They call attention to two great changes which distinguish current treatment of fractures from that of thirty years ago: (1) the demand for roentgenographic evidence of consolidation rather than clinical evidence alone and (2) the current belief that all fractures unite if immobilized long enough and that nonunion is never inevitable. A statement made by Jones in 1912 is

recalled by the authors: "We must realize that the academic period of consolidation authoritatively asserted is not accurate, and that bone which appear firm to the hand will yield after many weeks to the incidence of body weight." In addition to the general causes of delayed union, the authors consider three local causes outstandingly important: (1) interrupted immobilization, (2) infection and (3) distraction of the fragments. The authors present tables in which this series of fractures is analyzed from the standpoint of type of injury, location, duration and treatment. In conclusion, the following points are made: Uncomplicated fracture treated by simple manipulation and plaster union as quickly as in former years; ten to twelve weeks should be the minimal time of immobilization for fractures of the shaft of bones of the lower extremity; interrupted immobilization, distraction, infection and too early weight bearing cause delayed union; excessive traction, with or without distraction, causes marked delay in the healing of fractures of the tibia; operative reduction in skilled hands, even when meta-fixation is used, does not delay union; early weight bearing, no matter what type of support is used, should be discouraged, as its benefits are doubtful and its dangers real; fractures of the shaft of the femur should be reduced immediately and light continuous traction used subsequently to maintain length; the time of immobilization for fracture of the femur should not be influenced by the fear of stiffness in the knee joint, as it is due to other causes; infection of fractures and neighboring soft tissues causes serious delay and should be dealt with early but is not a cause of nonunion.

Peterson<sup>521</sup> presents an excellent study of 20 cases of neglected fracture of the femoral shaft

520. Watson-Jones, R., and Coltart, W. D.: Slow Union of Fractures with Study of 804 Fractures of Shafts of Tibia and Femur, *Brit. J. Surg.* 30:260-276 (Jan.) 1943.

521. Peterson, L. T.: Neglected Femoral Fractures. *J. Bone & Joint Surg.* 25:871-882 (Oct.) 1943.

in which treatment was begun at the Walter Reed General Hospital from several weeks to several months after injury. The article is well illustrated with roentgenograms. For treatment of the uncomplicated fracture suspension traction is the method of choice; its disadvantages are that it requires constant attention, the taking of frequent roentgenograms, nursing care and measures to prevent distraction. Immobilization with plaster alone after primary reduction is condemned because angulation and overriding can occur in the cast. Plaster immobilization should be used for emergency transportation only. Dual pin reduction and fixation are recommended only for relatively simple fractures of the shaft; this method is contraindicated for old fractures, fractures near joints and fractures with large free fragments. The disadvantages of the dual pin method are that it causes discomfort, that the resulting mobility of the knee does not meet expectations and that it may cause osteomyelitis. Open reduction and internal fixation with suitable nonirritating plates and screws are recommended as the treatment of choice where proper facilities are available. This should be done as early as possible, but open reduction does not guarantee union, and proper attention must be paid to blood supply and mechanics, including the avoidance of distraction. When open reduction must be done more than eight weeks after injury, bone grafting is recommended. The preferred method is massive grafting with maximal contact between the graft and the vascular portion of the host. The graft should be fixed with long metal screws. The simultaneous use of a metal plate allows earlier motion of the knee. The author describes several cases of neglected femoral fractures in which later treatment by these methods was successful.

Anderson and Burgess<sup>522</sup> believe that delayed union and nonunion of fractures of the shafts of long bones are usually a result of ill advised treatment, pointing out that in many cases the attending surgeon has failed to observe the basic principles of therapy for fractures. The authors call attention to various ways in which the three commandments for fractures, reduction, immobilization and preservation of blood supply, are daily being broken by conservative skeletal traction and by operative methods. They state that when these principles are efficiently applied over 90 per cent of slow unions are circumvented. They believe that nonunion can be prevented by a simple and practical system which exerts direct skeletal control over both proximal and dis-

tal fragments. The authors think that by the use of dual transfixion traction the care of fractures of the extremities is simplified, standardized and made available to all surgeons, regardless of location, who either by preference or by necessity are faced with problems involving fractures. [ED. NOTE (E. M. R.).—The authors' criticism is well taken but should be directed more at the attending surgeon and less at the method.]

Anderson and Finlayson<sup>523</sup> point out some of the pitfalls of the transfixion pin method for the treatment of fractures and discuss means of avoiding them. These authors think that complications can in a large measure be prevented and can be limited to a minimum approaching zero when the following technic is carefully employed. Transfixing pins should be inserted through the wide cancellous portion of the bone whenever possible; two pins, two wires or two half-pins at an angle to each other should be placed in each fragment. The transfixions should be used for traction only during the reduction; afterward they should provide "contraction" to keep the ends of the fragments in direct and immobilized contact throughout the whole period of repair. The authors think that employment of these clinically tested principles and insistence on ambulation, with active movement of muscle and joints, will be rewarded by earlier bony union than can be attained by any other method. Complications are said to be usually due not to use but to misuse of transfixion. Common errors arising from fear, unpreparedness or haste include improper placement of the pins, movement between fragments and transfixion, use of transfixion for skeletal traction instead of "contraction" and failure to use transfixion in this way so that the benefits of ambulation may be obtained. [ED. NOTE (E. M. R.).—Perhaps greater technical skill is required for the successful application of this method than for the use of more conservative measures.]

Davis<sup>524</sup> reports 6 cases illustrating the frequently observed causal effect of a powerful distracting force in delaying the union of fractures of the long bones. In his cases complete annular tears of the periosteum were demonstrated at operative exposure of the site of fracture. A theoretic explanation of the delayed union is offered, this being "misdirected flow of bone and soft tissue fluid" produced by the annular periosteal rent. In these cases nonunion was treated

522. Anderson, R., and Burgess, E.: Delayed Union and Non-Union: 90 Per Cent Preventable, *J. Bone & Joint Surg.* 25:427-445 (April) 1943.

523. Anderson, R., and Finlayson, B. L.: Sequelae of Transfixion of Bone, *Surgery* 13:46-54 (Jan.) 1943.

524. Davis, A. G.: Pin Distraction as Cause of Non-Union, *J. Bone & Joint Surg.* 25:631-643 (July) 1943.

with onlay grafts which were fixed by long metallic screws. Another type of distraction which may interfere with the healing process in fracture of the shaft of the tibia is emphasized by Stotz.<sup>525</sup> He believes that with tibial fractures, even when the fragments are in perfect apposition, a small gap may result from absorption of bone at the fracture line and that when the fibula is intact such a gap may result in delayed union or nonunion. He is also of the opinion that early union of the fibula, when there is a concomitant fracture of the tibia, may likewise cause delayed union or nonunion of the tibia. In cases in which the intact fibula is responsible for angulation of the tibia, in all cases of oblique tibial fractures in which after six weeks there is still springiness at the site of fracture and in many cases of frank pseudarthrosis, he advocates subperiosteal osteotomy of the fibula, with removal of from 0.5 to 5 cm. of the bone at a site remote from the tibial fracture. A plaster cast is applied for four to six weeks after operation. The patients begin walking on their casts after the first week. The author has practiced this operation since 1940 and has been satisfied with its results.

An important cause of pseudarthrosis, intraosseous neurofibroma, is emphasized by Green and Rudo.<sup>526</sup> They report a case in which pathologic examination showed neurofibroma to be a factor in the production of the fracture and in the retardation or prevention of union. They commend that in all cases of "congenital pseudarthrosis" the patient should be examined for stigmas of neurofibromatosis, which include café au lait spots, extraosseous tumors and roentgen evidence of other skeletal defects. In operations on patients with "congenital pseudarthrosis" the possibility that the process may be due to the presence of a neurofibroma should always be considered. If the neurofibroma is the cause of the pseudarthrosis, incomplete excision of the tumor with local recurrence may be a factor in nonunion. [ED. NOTE (R. B. R.).—This differentiation is important and should be kept in mind in all cases of congenital pseudarthrosis.]

*Operations for the Treatment of Delayed Union and Nonunion.*—Key<sup>527</sup> presents a review of various methods of bone grafting and discusses the indications for each. The operations used to secure union, in order of increasing com-

plexity, are the following: (1) multiple drilling of the fragments, (2) open reduction and internal fixation, with or without multiple drilling of the fragments, (3) step-cut operation and (4) various types of bone grafts, with or without internal fixation. All operations should be followed by adequate external fixation, usually by means of plaster casts. Key found the massive onlay graft to be most useful in the difficult cases; in some instances he used the Phemister modification, in which a massive graft is placed at the site of fracture without internal fixation. The author draws the following conclusions: (1) with the protection of the sulfonamide drugs, operations for delayed union or nonunion may be performed earlier than in the past; (2) the choice of operation depends somewhat on the surgeon in that the procedure should be one which he can execute satisfactorily; (3) the simpler procedures are followed by fewer complications than the more complex measures, but simple procedures will not always solve difficult problems, and (4) a simple operation undertaken early may save time for the patient, avoid a difficult late operation and result in a better limb.

Boyd<sup>528</sup> reports additional experiences with the dual graft technic, in which a cortical bone graft is placed on each side of the shaft at the site of nonunion. The indications and the operative technic are described. Boyd states that osseous union has been secured in 93 to 94 per cent of 511 cases of nonunion in which treatment with the single massive onlay graft, which has been described previously by Henderson, Campbell and Speed, was used. The dual graft, therefore, is reserved for more difficult cases in which there is loss of bone or some other unusual feature such as failure of a previous single graft. Nonunion with loss of substance near a joint is not considered a contraindication. In 18 of the 22 cases described in this report, treatment with the usual dual graft technic was employed. Treatment failed in 1 instance, a case of nonunion with extensive loss of bone near the elbow in which physical therapy was apparently started too early. In 1 case exacerbation of infection occurred but union was nevertheless obtained.

Armstrong<sup>529</sup> believes that the results of fractures of the shaft of the tibia are often imperfect because of a tendency for these injuries to be regarded as trivial, when in reality they

525. Stotz, W.: Resection of Fibula for Pseudarthrosis or Retarded Union of Tibial Fractures, *Bull. War Med.* 3:385 (March) 1943.

526. Green, W. T., and Rudo, N.: Pseudarthrosis and Neurofibromatosis, *Arch. Surg.* 46:639-651 (May) 1943.

527. Key, J. A.: Choice of Operation for Delayed and Non-Union of Long Bones, *Ann. Surg.* 118:665-680 (Oct.) 1943.

528. Boyd, H. B.: Treatment of Difficult and Unusual Non-Unions, with Special Reference to Bridging of Defects, *J. Bone & Joint Surg.* 25:535-552 (July) 1943.

529. Armstrong, J. R.: Method of Bone Grafting Tibia and Fibula, *Proc. Roy. Soc. Med.* 35:759-760 (Oct.) 1942.

are difficult to reduce and hold satisfactorily. He lists four absolute indications for bone grafting: (1) established nonunion, (2) malunion sufficient to cause serious disability, (3) inadequate reduction by conservative means and (4) extensive loss of bone. He names two relative indications for open operation: (1) delayed union in certain circumstances and (2) grossly unstable fractures. Armstrong advocates the massive sliding graft, or the split bone technic in which a portion of the tibial shaft is resected and reversed.

In another article Armstrong<sup>530</sup> discusses in more detail the massive sliding graft, or the so-called split bone technic, for fractures of the tibia. He exposes the tibia subperiosteally throughout its length, reduces the fracture and holds the fragments temporarily by Lowman clamps. He frequently finds it necessary to refracture or divide the fibula. He then takes the massive graft, of which one third is on the shorter tibial fragment and two thirds on the longer fragment, and reverses it, fixing the longer fragment across the site of fracture with four vitallium screws and placing the shorter fragment in the remaining tibial defect. The alinement is checked by roentgenograms before the wound is closed, and any necessary modifications are made. The fracture is then treated with plaster in the usual way. The author states that this operation is mechanically sound, its technic is simple, it involves only the injured limb and it is followed by rapid and certain union. [ED. NOTE (P. H. H.).—This method has been commonly employed for many years, and since the introduction of vitallium, screws made of that metal have been generally used for fixation of the graft. The conditions and circumstances of the fractures in which the author has employed the method are not mentioned, nor is the extent to which he has employed it. His statement concerning "rapid and certain union" must be regarded with some reservation.]

Butler,<sup>531</sup> in reporting on a series of 50 patients with fractures of the scaphoid bone for which a peg graft operation was performed, describes the technic. The operations were performed for nonunion, delayed union or recent fracture in which nonunion seemed probable. For 14 patients union was obtained in an average of three months, for 18 union occurred in an average of five months and the remaining 18 were still in

plaster or not available for follow-up studies. Owing to the difficulty of placing accurately a large drill in this small bone, the long axis of which lies at an angle of 45 degrees to the transverse plane of the wrist and 40 degrees to the long axis of the limb, as pointed out by Armstrong in 1941, a special arm rest made of aluminum was devised to hold the limb with the long axis of the scaphoid bone vertical. This arm rest is fitted with a shelf to hold a roentgen film in the correct position, so that roentgenograms can be taken at various stages during the operation. Brachial plexus block anesthesia was used. The bone peg was taken from the olecranon. A padded plaster cast was applied to the entire arm immediately after the operation. Twenty-one days later a skin-tight plaster cast was applied to the forearm and molded firmly around the arm and wrist joint almost to the interphalangeal joint of the thumb. The patient was then returned to light duty and came back monthly for supervision. [ED. NOTE (P. H. H.).—A mechanical aid for precision drilling in these difficult operations should be welcome. Its provision and an understanding of its application would seem to be the only drawbacks.]

Vere-Hodge<sup>532</sup> reports the case of a 21 year old flight mechanic in whom pain, weak grip and limited active motion of the wrist following fracture of the scaphoid bone were greatly improved by excision of the proximal fragment.

Thompson<sup>533</sup> describes a "telescoping V osteotomy" for the correction of angular and rotational malalignment in bones which are conoidal in longitudinal section. The smaller fragment is partially telescoped into the larger; the firm apposition of living bone fragments enveloped by periosteum results in considerable stability and prompt union. Plaster casts are used for immobilization. The author reports good results with this technic in diverse situations. While rather severe deformities are shown, the method is no less simple and secure for the treatment of mild ones.

*Volkman's Ischemic Paralysis.*—Albert and Mitchell<sup>534</sup> discuss the various theories of the pathogenesis of Volkmann's paralysis and describe 3 cases of vascular injury in the leg, ischemia of the muscles of the anterior tibial compartment, drop foot and massive late calci-

530. Armstrong, J. R.: Bone-Grafting in Treatment of Fractured Tibia and Fibula, *Lancet* 2:188-191 (Aug. 14) 1943.

531. Butler, A. A.: Bone Pegging Carpal Scaphoid, *Proc. Roy. Soc. Med.* 35:760-761 (Oct.) 1942.

532. Vere-Hodge, N.: Early Excision of Avascular Fragment of Fractured Carpal Navicular Bone, *Proc. Roy. Soc. Med.* 35:764 (Oct.) 1942.

533. Thompson, V. P.: Telescoping V Osteotomy: General Method for Correcting Angular and Rotational Disalignments, *Arch. Surg.* 46:772-779 (May) 1943.

534. Albert, M., and Mitchell, W. R. D.: Volkmann's Ischemia of the Leg, *Lancet* 1:519-522 (April 24) 1943.

fication and formation of an abscess. The ischemia was thought to be of the Volkmann type. The authors suggest that ischemia is due either to temporary arterial obstruction or to venous occlusion and that the resulting deformity depends chiefly on muscle tone in the affected part. The possible effect of skin-tight plaster casts and the importance of surgical intervention to relieve tension in the anterior compartment of the leg are stressed. Splinting will relieve the deformity

and prevent a part of it but will not restore power to the muscles. The chalky deposits and the abscesses of the late stage may require surgical removal. In the established case, a shoe for drop foot with a spring brace and lateral up-rights will improve function. It is suggested that more of these cases will be observed under wartime conditions and that calcification may be demonstrated in old cases of ischemic palsy of the forearm.

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## WOUNDS OF THE CHEST IN PACIFIC JUNGLE WARFARE

A REVIEW OF THIRTY-TWO CASES

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The character, clinical course and end results of penetrating war wounds of the chest are influenced by three general factors: (1) the size, irregularity, velocity and course of the penetrating missile; (2) the general physical condition of the soldier when wounded, and (3) the promptness of first aid and the early transportation of the wounded man to a hospital which has adequate facilities and personnel for the care of wounds of the chest.

A series of 32 patients with wounds of the chest are presented. They represent all of the patients seen in the hospital in which I have been serving during a relatively short intensive engagement. The men previously had all been in the same general physical condition, and they were all efficiently treated early by the same medical organization. Since these two general factors are similar, the cases of these patients wounded in Pacific jungle warfare are reviewed to illustrate the types of penetrating missiles, the damage resulting therefrom and the early results of treatment of the wounds.

The type of penetrating missile depends, of course, on the type of weapon utilized by the enemy. Obviously, wounds differ in land, sea and air combat, but even in the various types of engagements on land the weapons used and the wounds sustained differ greatly. In this war so many varieties of combat exist that the wounds sustained and the care required may differ considerably. The cases here presented will in no way be comparable to those seen after bombing raids, intensive artillery engagements or tank warfare on other fronts. The weapons utilized by the enemy in this engagement and therefore the wounds sustained are typical of Pacific jungle warfare.

Wounds caused by rifle and machine gun fire are essentially similar, and because it is often difficult to determine accurately the weapon used these have been combined. Japanese rifles are of .256 and .303 caliber, the most commonly used being the .256 caliber. Machine guns usually employed by the Japanese are of .303 and .256 caliber. In this series there were 11 cases in which the men were wounded by rifle or machine gun fire; in 8 of these they were wounded

by .256 caliber rifle fire. The exact specifications of weight, muzzle velocity and other characteristics of this rifle are not available to me, but the resulting wound is similar in many respects to wounds caused by the United States rifle. The wound of entrance is usually small, and the wound of exit is only somewhat larger unless bone is encountered. When bone is struck fragments of bone are often driven into the soft tissues, a larger area of tissue is damaged and therefore a large wound of exit results. The velocity of this shell is probably somewhat less than that of the American shell, as there seems to be more tendency for the bullet to lodge (fig. 1 A). Wounds caused by the larger (.303 caliber) shell are similar. In 3 cases the character of the wound was altered by the fact that the bullet struck some object on the soldier's person before penetrating. The fragments of the object struck were driven into the body, causing a larger, irregular wound of entrance. In 1 instance a knife handle was struck, in another a helmet and in the third instance a hand grenade, which fortunately did not detonate (fig. 1 B).

The most commonly seen wounds were caused by fragments of a Japanese 50 mm. mortar shell. Twelve men were wounded by this agent. The wounds caused by this weapon differ considerably from wounds caused by fragments of other artillery shells. The shell explodes on contact with considerable concussion. On detonation the wall of the shell disintegrates into many small fragments; there is even a powdering effect of some of the shell. The thin-walled brass detonator cap is also fragmented. When the soldier is wounded by the explosion of one of these shells at close proximity, the resulting wound is large and irregular and multiple small penetrations are seen at its base. The edges of the wound are blackened by many tiny powdery fragments which have been driven into the skin. At a greater distance dispersal of the fragments causes the resulting wound to consist of multiple widespread small perforations. Most of the powdery fragments have dissipated their velocity and are not seen. The fragments seen are portions of the cast iron wall of the shell,



which are irregular; they rarely measure over 1 cm. in diameter and usually lodge in the tissues. In addition, there may be thin fragmented strips of the detonator cap. These are irregular and rarely measure over 1 by 2 cm. (fig. 2 *A*).

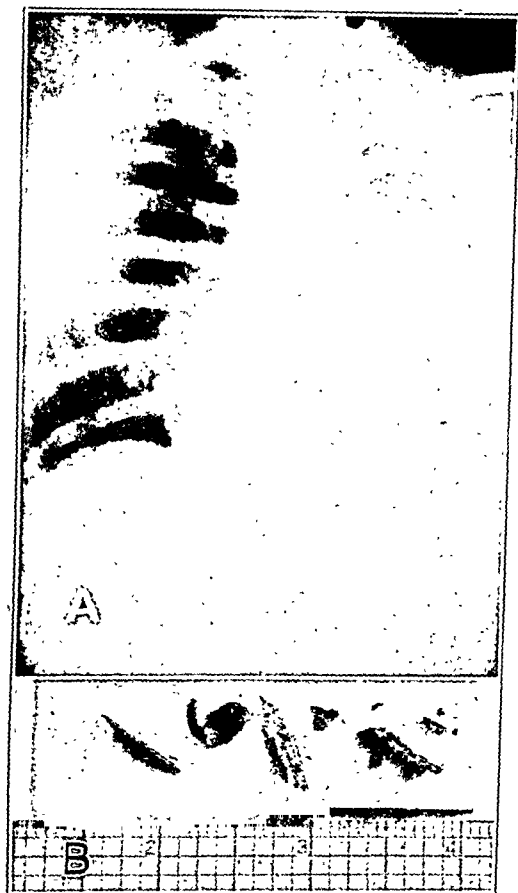


Fig. 1.—*A*, roentgenogram of the chest of a soldier wounded by a bullet from a Japanese .25 caliber rifle. *B*, fragments of the bullet and knife handle removed from the wall of the chest. The scale is in inches.

The roentgenologic appearance resembles a wound caused by a shotgun with irregular shot of varying size (fig. 2 *B*). Wounds caused by Japanese hand grenades are similar in many respects to wounds caused by 50 mm. mortar shells. The most common variety of grenade has a heavy brass top containing the pin and fuse (fig. 3 *A*). This top is usually not fragmented on detonation and apparently travels for a short distance only, as wounds caused by this object are rare. The wounds incurred close to the point of detonation are similar to those incurred near the burst of a 50 mm. mortar shell. The wounds incurred at a greater distance resemble the multiple perforations seen in those caused by the burst of a mortar shell at a distance (fig. 3 *B*). As there is no detonator cap,

no thin metallic strips are found in the wound; the foreign bodies found are small, irregular and indistinguishable from the fragments of the wall of the mortar shell.<sup>1</sup>

Larger caliber artillery was not extensively used by the enemy in this engagement; however, in this series there were 4 cases in which the men were wounded by shell fragments of this type. A roentgenogram of the chest of a soldier wounded by the fragment of a 90 mm. mortar shell is pictured (fig. 4 *A*). These wounds were indistinguishable from wounds caused by a fragment of any high explosive shell, as was described by Bailey.<sup>1</sup> They were large, ragged and irregular, with an extensive area of damaged tissue. The foreign bodies were likewise large, irregular, heavy fragments, which often carried pieces of clothing into the wound and usually lodged (fig. 4 *B*).



Fig. 2.—*A*, strip of a detonator cap of a Japanese 50 mm. mortar removed from the thoracic wall of a soldier. *B*, roentgenogram of the chest of a soldier wounded by fragments of a Japanese 50 mm. mortar.

It is frequently difficult to determine the exact causative agent of a penetrating wound. The wounds just mentioned were probably accurately

1. Bailey, H.: *Surgery of Modern Warfare*, Baltimore, Williams & Wilkins Company, 1941, vol. 1, p. 5.

classified by the patient's story and the character of the wound and foreign body (when the latter was available). In 3 cases, however, enough doubt as to the exact agent still existed that the wounds were left unclassified. They were

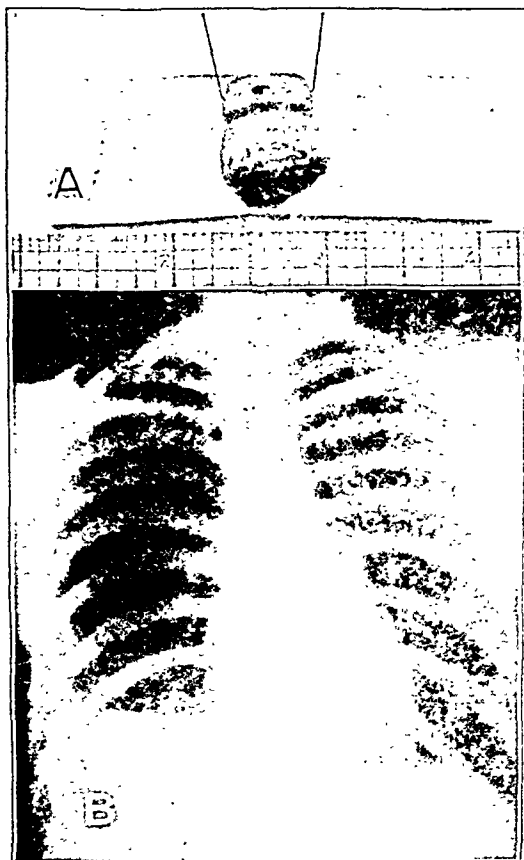


Fig. 3.—*A*, top of a Japanese hand grenade. This foreign body was removed from a soldier's neck. *B*, roentgenogram of the chest of a soldier wounded by fragments of a Japanese hand grenade.

probably caused by artillery fragments or exploding land mines.

Knife and bayonet wounds were not seen in his series; the ones seen in other campaigns differed in no striking way from knife wounds of the chest seen in civilian charity hospitals in large cities. There were no wounds caused by fragments of bombs. Wounds caused by shrapnel in the form of case shot were not seen in his area.

The importance of the location and course of a penetrating wound of the chest was emphasized in a previous publication.<sup>2</sup> I obtained no information in this engagement on those rapidly fatal wounds in which the heart or great vessels

are penetrated. In only 1 case in this series was a patient wounded in a dangerous area. He must be considered fortunate, as small shell fragments passed through his hand before penetrating the sternum and lodging in the musculature of the left ventricle (fig. 5).

The soldier's general physical condition is obviously an important factor in his immediate response to the wound as well as in the healing process. This is even more true in warfare than in civilian life. The presence of such endemic diseases as malaria, filariasis and hookworm infestation, which are seen in this area, complicates the soldier's convalescence. More important are such factors as acclimatization of the soldier and the associated disturbances in the fluid and electrolyte balance and hypoproteinemia or temporary vitamin deficiencies, due to an isolated position.



Fig. 4.—*A*, roentgenogram of the chest of a soldier wounded by a fragment of a Japanese 90 mm. mortar shell. The fragment penetrated the left side of the chest and lodged in the subcutaneous tissue of the posterior portion of the right side of the chest. *B*, fragment of artillery shell with attached piece of clothing removed from an infected pleural cavity.

2. Hardt, H. G., Jr., and Seed, L.: Comparison of the Course and Direction of Fatal and Nonfatal Gunshot Wounds of the Chest. *War Med.* 2:623-634 (July) 1942.

An important factor in the character of the soldier's wound is the presence of an obliterated pleural cavity, resulting from previous pleural disease. When a thoracic wound is sustained by

a soldier with an obliterated pleural cavity, the blood cannot escape into the pleural cavity, so bleeding into the pulmonary parenchyma occurs, as has been well illustrated in the monograph of Duval.<sup>3</sup> Roentgenologically, clouding of the



Fig. 5.—Roentgenogram of the chest of a soldier with hemopericardium, resulting from wounds caused by artillery shell fragments. *A*, posteroanterior view; *B*, lateral view.

pulmonary field in the region of the wound is demonstrable; the patient expectorates rather large amounts of blood during the first few days after being wounded and the clouding rapidly clears (fig. 6). Three cases of this type of damage were observed in this series, in all of which there was a history of previous respiratory disease with pleural involvement.

The soldiers whose cases are included in this series had been previously in excellent general physical condition. Most of them were combat-seasoned troops, and all were well acclimated to tropics. All men constantly took prophylaxis.

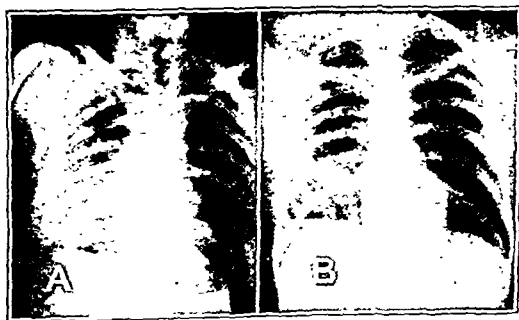


Fig. 6.—Roentgenogram of the chest of a soldier with hemorrhage into the pulmonary parenchyma, resulting from a wound caused by a bullet and a knife handle. *A*, taken immediately after the soldier was wounded; *B*, taken twelve days after he was wounded.

lactic drugs for malaria. This regimen was continued in this hospital, and all remained free of symptomatic malaria. Two cases of hookworm

infection were discovered in the routine examination for this parasite. Before and during the encounter the soldiers were adequately supplied with sufficient essential foods, fluids and vitamins.

Early and adequate medical care for penetrating thoracopulmonary wounds is vital to the welfare of the patient. The series here reported is of interest because of the promptness and efficiency which characterized the handling of the men in the forward areas. Many of the patients arrived at an adequately established hospital within an hour after being wounded. Only 1 patient required more than four hours to reach the hospital, which contained adequate facilities and a well trained team for thoracic surgical operations. In this single exception, the patient's aid party encountered an enemy ambush, and the patient did not reach a hospital until twenty-four hours after he was wounded. Because of the circumstances and the tactical situation it will rarely be possible in this or any theater to have as adequate an organization available so near to the front. The results in this series of cases illustrate well the importance of early and adequate care in the treatment of penetrating wounds of the chest.

#### CLINICAL MANIFESTATIONS

In 9 of the 32 cases the wounds were perforating, and in 23 they were penetrating, with the foreign bodies lodging in the tissues. In 31 cases the wounds of entrance were located in the safer areas of the chest, described in a previous paper.<sup>2</sup> The other case in which the wound was located over the upper part of the sternum has been mentioned elsewhere. In 15 cases the wound of entrance was in the anterior portion of the chest, in 4 it was in the left axillary region, in 2 the right axillary region and in 11 the posterior portion of the chest.

Shock was severe in only 6 cases. In most of the cases the clinical evidence of shock was not prominent enough to warrant recording; however all of the patients were given at least 300 cc. of plasma intravenously on admission to the first hospital, or in the aid station, regardless of their apparent good condition. It seems reasonable to assume that many cases of clinical shock were obviated by this prophylaxis. In the 6 cases in which there was clinical evidence of severe shock the patients were energetically treated with transfusions and plasma and responded well.

Hemoptysis was observed in 19 cases. It was slight and not frequently repeated except by those men with parenchymal bleeding, who were previously described. These men expectorated

3. Duval, P.: *War Wounds of the Lungs: Notes on Their Surgical Treatment at the Front*, New York, William Wood & Company, 1918.

blood for five or six days after being wounded. Dyspnea was noticed in 29 cases, but in 10 of these it was mild.

Hemothorax was present in 26 cases. It varied from the smallest amount detectable by roentgenogram to almost complete filling of the



Fig. 7.—*A*, roentgenogram of the chest of a soldier wounded by an artillery shell fragment. Moderate hemothorax is present. The fragment is at the extreme base of the pleural cavity. *B*, roentgenogram of the chest of a wounded soldier, which demonstrates moderate pneumothorax without hemothorax.

pleural cavity (fig. 7*A*). Pneumothorax in varying detectable amounts was present in 10 cases. In some cases pneumothorax was the dominant roentgenologic finding (fig. 7*B*).

Fractured ribs were demonstrated in 10 cases; in 6 of these more than one rib was fractured. Perhaps other costal fractures existed, but exact evidence was obscured by the hemothorax. The capula was fractured in 3 cases, the spine was fractured in 3 and the sternum and the clavicle were fractured in 1 instance each.

Subcutaneous emphysema was rarely encountered in this series.

#### COMPLICATIONS

In 1 case a bronchopleural fistula developed suddenly seven days after injury. The previously sterile hemothorax consequently became infected. Infected hemothorax developed in 2 other cases, in 1 of which it followed infection of the wound of the thoracic wall. The infected hemothorax in these 3 cases was drained surgically; in 2 resection of a rib was done, while in the third intercostal drainage was instituted. Hemolytic staphylococci were recovered from the infected pleural cavity in 2 cases and nonhemolytic staphylococci in the third. There were 3 instances of infection in the wound of the thoracic wall. The infection responded well to local therapy. In 2 cases evidence of pneumonitis in the injured lung was found. In these cases recovery was satisfactory after sulfadiazine therapy.

Local application of sulfanilamide crystals was used routinely for all wounds. The incidence of local infection was low, considering the type of wound, but it is impossible to determine whether the local use of sulfanilamide was an important factor.

There were no deaths in this series of cases at this hospital. Information is not available regarding early deaths from wounds of the chest in the forward areas. There were 2 patients with damage of the thoracic portion of the spinal cord. These patients were sent to the rear areas in satisfactory condition, but their ultimate prognosis was considered poor.

All patients in this series of cases were evacuated by air over approximately 900 miles (1,448 kilometers). Twenty-four of these stated that they experienced no change of their respiratory symptoms during the flight. Seven patients admitted some increase in dyspnea at high altitudes, and 1 required oxygen. During one portion of the trip, planes usually reach an altitude of at least 9,000 feet (2,743 M.). No untoward effects of evacuation by air were observed in any of these patients.

#### TREATMENT

The immediate treatment of the wounds consisted of application of sulfanilamide crystals locally and a dry dressing. Because patients arrived at a hospital so soon after being wounded, exploration and débridement of the wounds were done in almost every case. In 7 cases of open sucking pneumothorax the opening was closed. The pleural cavity was explored whenever extensive pulmonary damage or profuse bleeding was suspected. The wounds were closed primarily in 14 cases. Débridement was followed by application of petrolatum gauze and the wound was left open in 11 cases. Seven small wounds were treated by cleansing and dressing only. Crystals of sulfanilamide were frosted in every wound.

In spite of the fact that all of the wounds were seen early many of them were not closed primarily. This was due to the fact that many of the patients with wounds caused by mortar shells had such a large area of damaged tissue and so many foreign bodies that complete débridement could not be performed without removal of an excessive amount of soft tissue. These patients were treated by partial débridement, and the wound was packed open. The wisdom of not closing extensive wounds due to mortar shells was illustrated in 2 cases in which closure was attempted. Infection of the wound developed in both cases.

Secondary surgical operation was done for continued pulmonary bleeding in only 1 case.

In 3 cases the infected hemothorax was drained surgically. Exploration of the pericardial cavity for persistent hemopericardium was done in 1 case. Two wounds which had been packed open were closed secondarily.

Considerable variation of opinion has existed in medical literature regarding the care of hemothorax of traumatic origin. In this intermediary hospital the following indications for aspiration have been used, with satisfactory results:

1. Use aspiration and replacement with air during the first seventy-two hours after the wound is incurred if excessive dyspnea exists or if continued bleeding from the pulmonary parenchyma is suspected.

2. If a persistent daily temperature reaching 100 F. exists with no other source of fever present, aspirate the blood. Do not replace it with air.

3. Do diagnostic aspirations frequently.

4. Allow asymptomatic hemothorax to remain undisturbed.

None of the patients in this series were seen in this hospital within seventy-two hours after injury; hence aspiration and replacement with air were not used. They were used in 3 cases in the forward hospitals.

Diagnostic aspiration was done thirty-four times in 21 cases.

A daily elevation of temperature exceeding 100 F. developed in 4 cases in this series. Aspiration was done. In all of them the temperature promptly decreased. Subsequent roentgenograms in 3 revealed no reformation of fluid.

In the fourth the patient had extensive hemothorax and effusion and was evacuated from hospital for other injuries before the final result could be determined.

The described regimen of therapy has been used in all cases of traumatic hemothorax served in this hospital. Aspiration for fever in the presence of sterile hemothorax has yielded similar good results in cases from other campaigns. In some cases in which effusion for after aspiration, repeated aspiration may be required.

#### SUMMARY

A series of 32 cases is summarized to illustrate the types of penetrating wounds of the chest and the causative agents seen in Pacific jungle warfare.

Because of the multitude of foreign bodies in the large areas of damage to soft tissue caused by fragments of Japanese 50 mm. mortar shells and Japanese hand grenades, wounds of this nature are best treated by limited débridement and petrolatum gauze packing.

Plasma given early, prophylactically, proved to be a potent factor in decreasing the incidence of clinical shock.

Treatment of traumatic hemothorax in the intermediary hospital according to the outline presented gave satisfactory results. Patients with persistent fever and sterile hemothorax were successfully treated by aspiration alone.

Septic complications in this series were minimal.

No ill effects resulted from evacuation by air of patients with thoracopulmonary wounds.

## A LABORATORY COURSE IN THORACIC SURGERY

EXERCISES IN THE PERFORMANCE OF SURGICAL PROCEDURES ON THE THORAX  
WITH A DISCUSSION OF THEIR CLINICAL APPLICATIONS

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AND

COMMANDER WILLIAM LISTER ROGERS (MC)-V(S), U.S.N.R.

The various operations employed in thoracic surgery, simple as well as complex, are easily demonstrated and performed on living anesthetized animals. In a course in thoracic surgery designed for members of the Army Medical Corps, we demonstrated the procedures, which were then performed on animals by the members of the class.

The animals (dogs) are anesthetized with intravenously administered pentobarbital sodium (35 mg. per kilogram of body weight). Adequate respiratory exchange is maintained by introducing a no. 28 (French) rectal catheter into the trachea and connecting it with a positive pressure apparatus. Should the pentobarbital sodium become ineffective, ether is administered through this apparatus. Although the operations were performed on anesthetized animals, the following discussions and descriptions of technic accompanying each procedure refer to human subjects.

### 1. ASPIRATION OF THE CHEST

*Practical Exercise.*—Aspiration of the chest is performed on an anesthetized animal with the following points in mind.

*Clinical Considerations.*—Aspiration is more comfortably and more accurately performed with the patient in the sitting position, if practicable, and the patient's feet over the side of the bed supported on a chair; an assistant is assigned to the sole duty of supporting the head and shoulders of the patient. Previous moderate sedation is desirable to allay apprehension and cough. Figure 1 shows the sterile instrument tray provided for aspiration. This sterile tray should contain two straight hemostats, 1 thumb forceps, a no. 11 Bard-Parker blade, a 10 cc. syringe with a hypodermic needle and a long fine needle

for deeper infiltration of the tissues with procaine hydrochloride and a 50 or 30 cc. syringe with a large aspirating needle with a short bevel and a two way stopcock or a 3 inch (7.6 cm.) rubber tube interposed between the syringe and the needle.

Since aspirations must occasionally be repeated, they should be painless and of course aseptic. The painlessness is particularly important for children. Gloves are not necessary. Gloves used under the conditions surrounding an aspiration are soon contaminated and become a menace rather than a protection. The various articles on the instrument tray are not removed with the fingers but with a sterile thumb forceps, so as to maintain the sterility of the tray throughout the procedure.

The site of aspiration for the purpose of removing fluid depends in general on the clinical signs, but when it is performed for the relief of dyspnea the needle is inserted in the posterior axillary line in the seventh interspace or above, to avoid injury to the diaphragm, which may be high.

The skin at the site selected for aspiration is infiltrated with 1 per cent procaine hydrochloride solution, with a fine hypodermic needle; this is followed by infiltration of the deeper intercostal tissues with a long fine needle. The skin is incised for 1 mm. with a no. 11 Bard-Parker blade, to avoid passing the aspirating needle through potentially infected hair follicles and sebaceous glands. An aspirating needle of large bore is introduced through the anesthetized area; it must hug the upper border of the lower rib to avoid the neurovascular bundle which lies along the inferior border of the rib. When severe pain accompanies aspiration, it is evident that this precaution has not been observed. Resistance is encountered as the needle penetrates the tissues. After the needle has encountered fluid, it is advanced 2 mm. more, and a small hemostat is placed on the needle flush with the skin so that the needle can be fixed in this position throughout the aspiration.

This course was given in the surgical laboratory of the Stanford University School of Medicine in November 1942, April 1943 and again in June 1943.

The opinions contained herein are the private ones of the authors and are not to be construed as official or as reflecting the views of the Navy Department or of the naval service at large.

If available, a two way stopcock is interposed between the syringe and the needle, which permits controlled discharge of fluid into a container and regulation of the introduction of air, if this is found desirable. If a stopcock is not available, a small segment of rubber tubing is interposed between the syringe and the needle, which may be clamped by a hemostat when the syringe is detached for discharge of fluid; hence an air-tight system is maintained throughout the aspiration. Moreover, accurate measurement of the amount of air and fluid removed from the chest is made possible.

If the fluid is amber but clear, only enough fluid is aspirated—about 75 to 100 cc.—for diagnostic studies: culture, determination of specific gravity and cell count, acid-fast and gram staining of the centrifugated sediment and injection of fluid into a guinea pig.

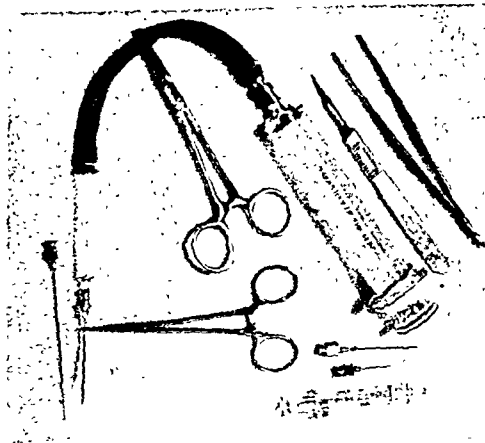


Fig. 1.—Sterile instruments needed for aspiration of fluid from the chest: a 5 or 10 cc. syringe, one hypodermic and one no. 22 needle, a thumb forceps, one no. 11 Bard-Parker blade, two hemostats, two aspirating needles of wide bore and short bevel no. 15 and no. 18, and one 30 or 50 cc. syringe with a short rubber tube and a glass adapter interposed between the needle and the syringe. (See text for technical details.)

If the fluid is bloody, as with cancer of the pleura or lung, about 200 cc. is aspirated, diagnostic studies are performed and the fluid is centrifugated to obtain a "button" of cells for embedding in paraffin and for subsequent microscopic section.

If the fluid is foul-smelling or obviously purulent though thin, immediate, continuous intercostal air-tight tube-under-water drainage is instituted (section 3).

If the pus is thick with much fibrin and restricted to a localized area, according to roentgenograms, resection of a small segment of rib or a short intercostal incision for washing out the fibrin and for the insertion of a mushroom-tipped catheter is in order (section 4).

Clear amber fluid obtained from a chest the presence of a high temperature and unilate abdominal symptoms, after an abdominal operation or an acute abdominal episode, suggest subdiaphragmatic or an intrahepatic abscess.

Fluid in the chest following a penetrating wound is due either to bleeding or to effusion. The mere presence of blood may not be harmful, but if it and air, or air alone, fill an entire hemithorax and produce dyspnea and circulatory embarrassment by a shift of the mediastinal aspiration is urgently indicated. Aspiration of air alone in pneumohemothorax may be sufficient to control the dyspnea. If aspiration is found necessary within twenty-four to forty-eight hours after injury, only enough blood is removed to control the dyspnea to a point of comfort, since further aspiration may reopen bleeding point. Usually the removal of 400 to 500 cc. of blood will suffice. We do not believe that replacement of blood by air is necessary or desirable as it is difficult to understand how a bleeding vessel can be more effectively closed by pressure due to air than by pressure due to hemothorax. Moreover, we believe that early reexpansion of the upper lobe is most important in reestablishing normalcy in the chest and should not be interfered with or delayed by the introduction of air. Not infrequently fluid which may at first be extremely bloody or serosanguineous later becomes purulent. Development of empyema in the presence of a collapsed lung may introduce the additional hazard of failure of reexpansion of the lung. Air free in the thorax tends to produce a collapse of the upper lobe. In the presence of pus the inflamed visceral pleura becomes thickened and rigid, and in this state the upper lobe may become fixed by adherence along the similarly inflamed mediastinal pleura. When this occurs its reexpansion is most difficult and may be greatly delayed or even prevented entirely (fig. 2). Thoracoplasty may be necessary before complete cure can be effected.

If dyspnea promptly recurs after the initial aspiration of blood for dyspnea, it is evident that bleeding is still severe, and a thoracotomy may be indicated to control it (section 9). Such bleeding may be due to wounds of the intercostal, internal mammary, hilar or mediastinal vessels. The blood may also come from a laceration of the lung, the pericardium or the heart, or it may even come through a rent in the diaphragm, resulting from injuries to such intra-abdominal structures as the liver. The site of the wound and a roentgenogram disclosing the location and probable course of a retained foreign body will assist in determining what structures may be involved.

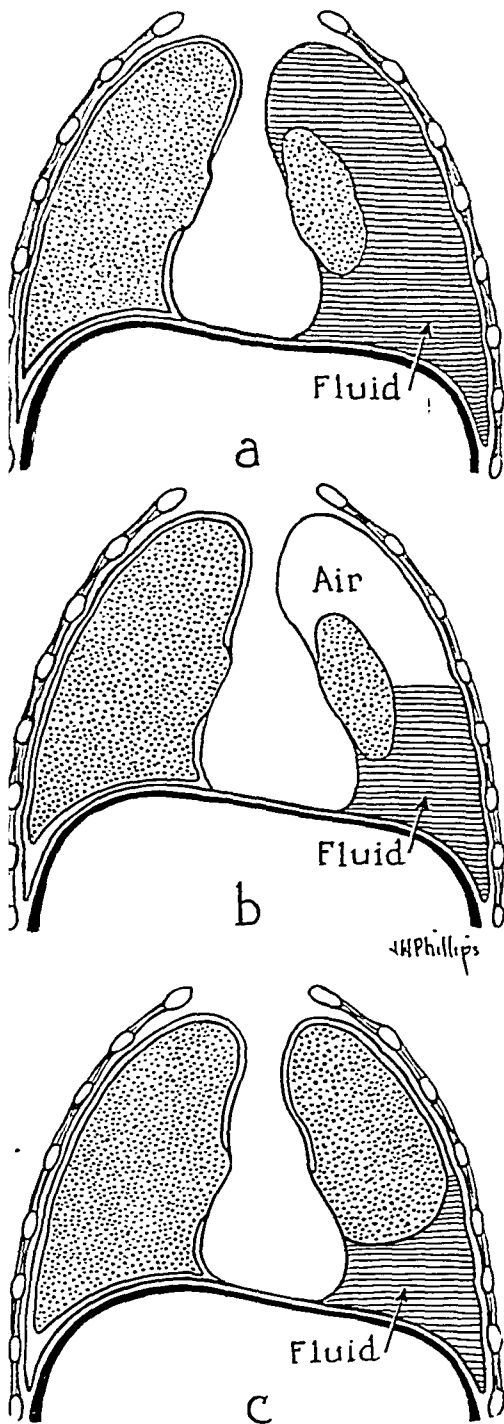


Fig. 2.—(a) Large effusion into the left side of the chest. (b) Partial aspiration of fluid and replacement by air. In an active patient accustomed to sitting up, air tends to accumulate at the top of the pleural space and fluid at the base. Development of empyema then threatens fixation of the upper lobe in the collapsed state by inflammatory adherence of the visceral and mediastinal pleuras, thus greatly complicating elimination of the empyema cavity by reexpansion of the lung. (c) After aspiration without replacement by air, fluid tends to accumulate at the base, the upper lobe reexpands, the pleuras usually become adherent with the lung expanded and if empyema develops it is localized rather than massive.

In the aspiration of fluid that has been present in the chest for some time, it is desirable not to remove more than 500 cc. at one sitting or to remove any beyond the point where pain is produced. If pain occurs, sufficient air should be introduced through the aspirating needle to control it, but in general replacement of serosanguineous fluid by air serves no useful purpose and should not be done, for reasons outlined previously. Occasionally, it may be desirable to introduce 100 to 150 cc. of air after partial aspiration to aid the roentgenologist in outlining a cavity or in bringing the contour of the intrathoracic structures into relief.

Fluid obtained by aspiration should be subjected to the following studies: making of a culture, determination of red and white cell counts and of hemoglobin content and immediate staining of a smear on a slide for detection of organisms. If aspirations are again necessary, these studies should be repeated after each aspiration. The information so gained may determine the further course of treatment. If the concentration of blood remains high at the second aspiration for dyspnea, it may be evidence of continued bleeding, which may require thoracotomy for its control. If fluid is less concentrated at the second aspiration, effusion is indicated and bleeding has probably ceased. If organisms are found in the smear, early empyema is suspected, and prompt establishment of air-tight intercostal continuous drainage will shorten convalescence greatly.

In general, hemothorax without symptoms, even though it is extensive, may be disregarded in the early period following injury. Remarkably rapid absorption of even large collections of blood has been observed. If there is no evidence of absorption after two or three weeks, aspiration becomes necessary and may need to be repeated. Alteration in relations of pressure within the thorax after one aspiration may lead to absorption of the remaining fluid. On rare occasions massive hemothorax may clot and can be evacuated only by thoracotomy, followed by immediate closure of the operative wound without drainage. Blood which has a tendency to clot immediately on aspiration suggests a massive injury to the lung or pleura or an incipient infection.

## 2. INSERTION OF NEEDLE FOR TENSION PNEUMOTHORAX

*Practical Exercise.*—A needle is inserted into the chest of an anesthetized animal and 400 to 600 cc. of air introduced with a syringe to which a two way stopcock has been attached. Enough air is introduced to produce increasing dyspnea. The needle is withdrawn, and the chest is aspi-



rated by inserting a needle to which a piece of rubber tubing has been attached. The rubber tube is placed under water to show the escape of air.

*Clinical Considerations.*—Severe dyspnea occurring promptly after injury may be due to tension pneumothorax incident to a laceration of the lung, bronchus or trachea, to a sucking wound without escape of air or, even more commonly, to a crushing injury of the chest in which it may not be suspected. Distinct high-pitched resonance on percussion with absence of breath sounds indicates pneumothorax. After anesthetization of the tissues with procaine hydrochloride the aspirating needle is usually introduced anteriorly in the second or third inter-

and effectively replace the more cumbersome under-water seal. The escape of air usually ceases after thirty-six to forty-eight hours, at which time the needle may be withdrawn. Should the escape of air through a needle not be sufficient to control the dyspnea or the tension within the chest, a tight intercostal drainage with catheter must be established (section 3).

### 3. ESTABLISHMENT OF AIR-TIGHT INTERCOSTAL DRAINAGE FOR MASSIVE EMPYEMA

*Practical Exercise.*—A catheter is introduced into the chest of an anesthetized dog through the intercostal space, with the following points in mind:

*Clinical Considerations.*—Air-tight drainage is indicated in massive purulent effusions occurring early in the course of pneumonia, particularly in children, and in diffuse streptococcic or staphylococcic pneumonia when the establishment of open pneumothorax might cause collapse of so much of the remaining good lung as to produce fatal embarrassment of respiration. It is also indicated in the early stage of empyema complicating a penetrating wound of the thorax. Occasionally air-tight intercostal drainage is necessary to control tension pneumothorax. Continuous air-tight drainage should be used only in the presence of infected fluid, as demonstrated either by smears or by culture. It should not be used for clear tuberculous, cancerous or post-traumatic noninfected bloody effusions.

The optimum locations for the insertion of the intercostal catheter in the presence of a massive effusion lie in the area between the median and posterior axillary lines in the sixth, seventh or eighth interspace. The tissues are infiltrated thoroughly from the skin through to the pleura with a 1 per cent solution of procaine hydrochloride. The presence of pus is first proved by aspiration. The skin is incised for about 1 cm. A trocar and a cannula, which are large enough to accept a no. 22 (French) catheter, are introduced by rotary motion and by slow, steady pressure, penetrating the intercostal tissues and hugging closely the upper border of the lower rib. The catheter is prepared before insertion by making two additional lateral openings near the tip on opposite sides of the catheter (fig. 4). Two results are achieved thereby: (a) These openings provide a flexible tip which will not erode the lung as the latter reexpands, as would a hard, rigid tube; (b) three apertures in the catheter insure drainage through at least one opening should the other two be covered by a reexpanding lung or by fibrin. The catheter is

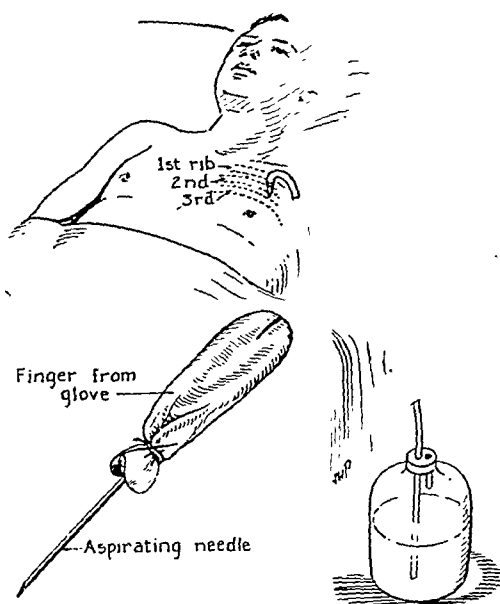


Fig. 3.—Aspiration of air from the chest through the second or third interspace anteriorly in or just lateral to the midclavicular line. Constant escape of air under water may need to be provided. When transportation is necessary, a finger cot (the tip of which has been slit) should be tied to the end of the needle and the needle fixed to the thoracic wall with adhesive tape. No dressing is necessary unless fluid escapes as well.

space in the nipple line. There may be a whistling release of pressure through the needle and prompt relief of the dyspnea. If air continues to escape, the needle should be connected with a rubber tube for continuous under-water drainage (fig. 3). If the patient is to be transported, instead of rubber tubing a soft rubber finger cot, a finger of a rubber glove, or a soft rubber sheath perforated at the end should be applied to the needle. This will permit the escape of air but prevent its reentry during inspiration

ched securely to the thoracic wall, not by a re through it but by narrow strips of adhesive applied around the catheter and to the thoracic wall; these narrow strips are in turn held in place by broad straps of adhesive tape tied to the thoracic wall. A glass Y tube is introduced into the catheter, with one arm of the Y to receive the rubber tube leading to a large glass bottle on the floor—the tube is to be under water—and the other arm to receive the rubber tube leading to an infusion bottle for irrigation with a saline solution, to maintain patency of the catheter and to wash out the cavity. If the patient is to be transported and under-water drainage is not practicable, a finger cot which has been attached at the end may be tied securely to the end of the catheter. If drainage is profuse, a volumi-

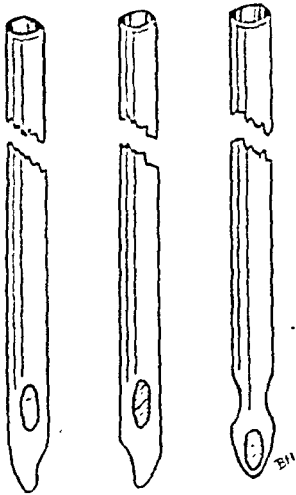


Fig. 4.—Preparation of a catheter for introduction into an intercostal space to provide air-tight drainage. It includes cutting two holes on opposite sides just proximal to the tip, in order to insure at least one opening for drainage should the other openings be closed by overlying lung or fibrinous folds.

as dressing must be applied. If drainage with the catheter is for tension pneumothorax, no dressing is needed.

If pus is thick and fibrinous it may be desirable to insert a second catheter in another intercostal space for continuous irrigation with saline solution, aqueous solution of chloroazodin or diluted solution of sodium hypochlorite. After five to ten days the original catheters may become occluded and may be replaced with larger-sized catheters to maintain air-tight drainage. When the empyema becomes limited by pleural adhesions, it may be necessary to enlarge the opening of the catheter in the intercostal space or to resect a segment of rib for more adequate and complete drainage.

#### OPEN DRAINAGE FOR LIMITED OR LOCALIZED EMPYEMA BY INTERCOSTAL INCISION OR BY RESECTION OF A RIB

*Practical Exercise.*—Resection of a rib of an anesthetized animal is performed, with the following points in mind:

*Clinical Considerations.*—When empyema is limited by visceroparietal pleural adhesions, open drainage is indicated for prompt and complete evacuation of pus. The site for dependent drainage by aspiration is determined, with the lowest needle through which pus has been obtained being left in place. A short intercostal incision is made, with the area under local anesthesia, or a 3 to 4 cm. segment of rib is excised. It is important not to strip periosteum from rib that is not removed; that is, all rib denuded of its periosteum must be excised to avoid osteomyelitis of the exposed devitalized rib. When available the cutting cautery may be used in mobilizing the rib and its periosteum. The pleura may also be incised with the cutting cautery, a small segment of the parietal pleura being removed for microscopic study. This is important to avoid missing the recognition of empyema due to tuberculosis. Bleeding points are controlled by ligatures, and sulfonamide compounds in powdered form are liberally applied to the cut costal surface and to exposed tissues before the pleura is incised and before pus is permitted to contaminate the tissues. Several methods for maintaining drainage are available: After complete evacuation of the cavity of all masses of fibrin and pus, a large mushroom-tipped catheter drawn flush with the parietal pleura may be inserted, and semi-closed drainage may be maintained. A soft rubber tube, 8 to 10 mm. in diameter and 10 to 12 cm. long with the ends open and two lateral openings near the inserted end, may be used. A safety pin through the tube outside the thorax permits fixation of the tube. A finger cot with the distal tip slit for 2 cm. is fastened to the end of the tube by a circular ligature (fig. 5). The wound is semisealed with petrolatum-treated strips and massive dressings applied under a circular chest binder. No suturing of the wound is necessary.

#### 5. SEMIOPEN DRAINAGE OF CHRONIC EMPYEMA BY SUTURING A SKIN FLAP TO THE PARIETAL PLEURA (ELOESSER)

*Practical Exercise.*—A skin flap is prepared, the rib is resected and drainage is established for presumed chronic empyema, with the following points in mind:

*Clinical Considerations.*—The establishment of a semiepipithelized drainage tract provides an opening during cough and forced expiration but

closure during inspiration; this will create conditions that will gradually expand a lung long collapsed by chronic empyema, whether pyogenic or tuberculous in origin.

Several considerations determine the location of the flap (fig. 6):

The base of the U-shaped flap should lie above the apex. The base is customarily 3 to 4 inches (7.5 to 10 cm.) across, with the length variable, but also approximately 3 to 4 inches and the apex is usually about  $1\frac{1}{2}$  inches (4 cm.) in width. It should be placed so as to provide dependent drainage with the patient in the upright position. This may be determined by centgenograms taken after the introduction of

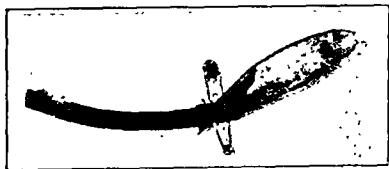


Fig. 5.—“No back draft drain”: rubber tube with two lateral and one terminal opening for insertion into the empyema cavity, the exterior end of which is covered with a finger cot or a finger of a glove the tip of which has been split, which permits escape of pus but prevents entrance of air into the cavity.

contrast medium, like iodized poppyseed oil, through a sinus tract, by a thoracotomy wound or by an aspirating needle—or by aspiration at different intercostal levels. If the empyema involves the lower part of the chest, the flap must be at least a rib and an interspace above the diaphragmatic attachment to the thoracic wall, so that the subsequent tendency of the diaphragm to rise will not occlude the opening. The flap should not be placed over the scapula or near the lower angle of the scapula, since motion of the shoulder girdle would tend to displace the apex of the flap from its attachment to the parietal pleura. The flap is so placed that the rib to be excised lies at the junction of the upper and middle thirds of the flap. If shrinking of the rib cage has occurred, due to the underlying inflammation, it often is desirable to remove small segments,  $1\frac{1}{2}$  inches (4 cm.) long, of two ribs. The ribs are mobilized, preferably with a cautery, so as to avoid early regeneration of the rib. A rectangular area of the parietal pleura beneath the excised ribs is removed with the cautery. The excised portion of the pleura must be sufficiently large so that the apex of the flap does not completely occlude the opening. A specimen of the excised pleura could be sent to the laboratory for microscopic study. If segments of two ribs have been removed it is advisable to excise the neurovascular

bundle below the upper excised rib. The distal third of the flap is then denuded of its subcutaneous fat. The apex of the flap is sutured with two or three mattress sutures of silk or cotton to the upper border of the defect in the thickened parietal pleura, with small, full-curved cutting needles. No attempt whatever is made to close the raw surface produced by this maneuver. To facilitate immediate drainage and to promote adherence of the flap to its new bed, a short rubber tube, about 3 inches (7.5 cm.) long, is inserted through the thoracic wall, to the external end of which is tied the finger of a rubber glove the tip of which has been slit (fig. 5). Petrolatum-treated strips are applied to the tip of the flap, snugly around the tube and over the raw surface of the wound. A large pad held in place by a tight binder completely encircling the chest completes the dressing. After seven to ten days the tube is removed; the hole gradually contracts, and it is soon evident that a negative pressure is being built up inside the empyema cavity by escape of pus and air during coughing and forced expiration and by closure of the opening during inspiration. Even in the presence of a bronchial fistula it has been found efficacious in providing adequate drainage and gradual re-expansion of the lung.



Fig. 6 (Patient A. N.).—(a) Eloesser flap two days after operation, on Jan. 19, 1944, for drainage of posterior empyema cavity, which followed an abdominal thoracic gunshot wound of the lower portion of the chest. Small 3 cm. segments of the seventh and eighth ribs were removed. Note the size of the resulting wound and the absence of sutures except three invisible ones, which approximated the tip of the skin flap to the parietal pleura. (b) Appearance of the rapidly closing external wound on February 5, within nineteen days after operation.

## 6. PENETRATING WOUNDS OF THE THORACIC WALL

*Practical Exercise.*—An anesthetized animal is prepared for this exercise by removal of a portion of one rib to create a sucking wound. The dangerous effects of such a wound are demonstrated by withholding temporarily the positive pressure anesthesia. Severe dyspnea incident to the transfer of atmospheric pressure

to the intact sound side by a flexible mediastinum is at once apparent. The varying effects of the size of the sucking wound are also demonstrated.

*Clinical Considerations.*—If only a single wound of entrance is present, a roentgenogram of the chest and a scout film of the abdomen should precede definitive treatment to ascertain the location of the foreign body. Emphysema of subcutaneous tissues and hemoptysis, however slight, give evidence of a contused or lacerated lung, bronchus or trachea. Emphysema of the mediastinum may be productive of great dyspnea and may be fatal. A rapidly spreading emphysema of the neck usually accompanies mediastinal emphysema, both of which may be relieved by an incision made just above the sternum. After sharp division of the skin and platysma muscle, the tissues are spread by blunt dissection, and separation of the sternohyoid muscles in the midline gives access to the loose areolar and fatty tissue just above and posterior to the upper border of the sternum. Blunt and digital separation

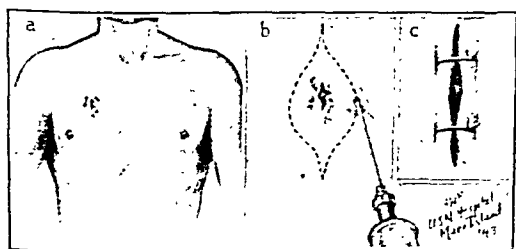


Fig. 7.—Jagged wounds of entrance or exit should be excised under local anesthesia and closed with widely spaced sutures or left unsutured if the sucking hole in the thoracic wall is easily controlled by a petrolatum dressing.

of these tissues will avoid traumatizing thin-walled veins in this area. A soft rubber tube or a tissue drain is introduced to permit continuous escape of air.

Severe bleeding from the mouth is not easily controlled, but the precaution must be observed of placing the patient with the head and thorax dependent, to facilitate drainage and to avoid his drowning in his own blood. Administration of large doses of morphine is indicated to allay apprehension and to decrease respiratory movement.

Small cleancut wounds of entrance and exit without powder burns or obvious devitalization of skin require simple dressing only. Jagged wounds with obvious traumatization of skin and underlying tissues require débridement and loose closure (fig. 7) to prevent local infection, spreading phlegmon of the thoracic wall or extension to an underlying hemothorax. Local

anesthesia is employed, with the tissues to be infiltrated well away from the area of injury so as not to neutralize the sulfonamide compounds which will later be introduced into the wound. Devitalized tissue is excised, and foreign material and bits of unattached fragments of rib are removed (fig. 8). Sulfonamide drugs in powdered form are introduced liberally to every nook and cranny of the wound, by mixing the powder with tissue fluid and blood and smearing this suspension throughout the wound with the gloved finger or instrument. Muscles are closed loosely with few sutures, the skin may be left open or closed loosely and petrolatum gauze and a firm dressing are applied. If the wound is limited to the thoracic wall without communication with the pleural cavity or if only a small opening exists which can easily be controlled with gauze, the wound should be lined with petrolatum or sulfathiazole gauze and a firm dressing applied without the use of sutures.

Large open wounds of the thoracic wall suck in air with each respiration. This collapses the lung on the side of the lesion instead of inflating it. In young persons the flexible mediastinum will shift with inspiration to the uninjured side because of negative pressure on that side. This still further reduces expansion of the lung and aeration of the blood, and severe dyspnea, if not death, is the inevitable result. Closure of these wounds is, therefore, imperative and life saving. If facilities for an operation are not immediately available, the wound must be covered or filled with petrolatum or plain gauze and the dressing held firmly in place by adhesive tape straps or broad bandages completely encircling the chest. Occasionally it may seem desirable to close such a wound immediately under local anesthesia. After closure it is desirable to remove as much air as possible from the pleural space by simple aspiration of the chest.

Occasionally, also, a small perforating wound will suck air but prevent its escape, with the result that positive pressure or tension pneumothorax is built up. This may be even more dangerous to life than a wound that permits both sucking and escape of air. The great need of early recognition of such a mechanism is obvious, as it may be necessary temporarily to enlarge such a wound to permit escape of air until complete closure by operation or by dressing can be performed.

#### 7. CARE OF SUCKING WOUNDS COMPLICATED BY INTRATHORACIC INJURIES

*Practical Exercise.*—Through a thoracotomy incision, the lung and the hilar tissues are exposed, a laceration of the lung is repaired, a

partial and a complete lobectomy are performed and the hilar vessels to a lobe are individually ligated. The phrenic nerve is identified as it courses over the pericardium, is pinched to illustrate contraction of the diaphragm and then crushed to demonstrate relaxation and elevation of the diaphragm. The diaphragm is incised in the direction of its muscular fibers and the abdomen explored through the opening. A tear of the liver is produced, and bleeding is controlled by muscle tamponade or by gauze packing, the gauze emerging through a separate stab wound in the lateral abdominal wall below the diaphragm. Drainage of a large tear in the liver is effected by soft rubber tissue drains, which also escape from a separate opening in the abdominal wall. A tear in the stomach is produced and repaired. Transpleural-transdiaphragmatic splenectomy is performed. A segment of small bowel

If enlargement of the existing wound by intercostal incision permits adequate inspection of the pleural cavity, this may be done. If not the wound should be debrided and closed after exploratory thoracotomy has been performed through a site of election. For exposure of the lower part of the chest and diaphragm, an incision in the posterolateral portion of the eighth interspace is effective (section 10). For exposure of the anterior portion of the chest at the hilus, an anterior incision through the fourth interspace with division of the fourth and third costal cartilages will suffice (section 9).

After an intercostal incision is made the ribs are spread with a self-retaining retractor. The fluid and the clotted blood are sucked out. Bleeding from intercostal, internal mammary, hilar or mediastinal vessels or from a lacerated lung should be searched for. Bleeding points are con-

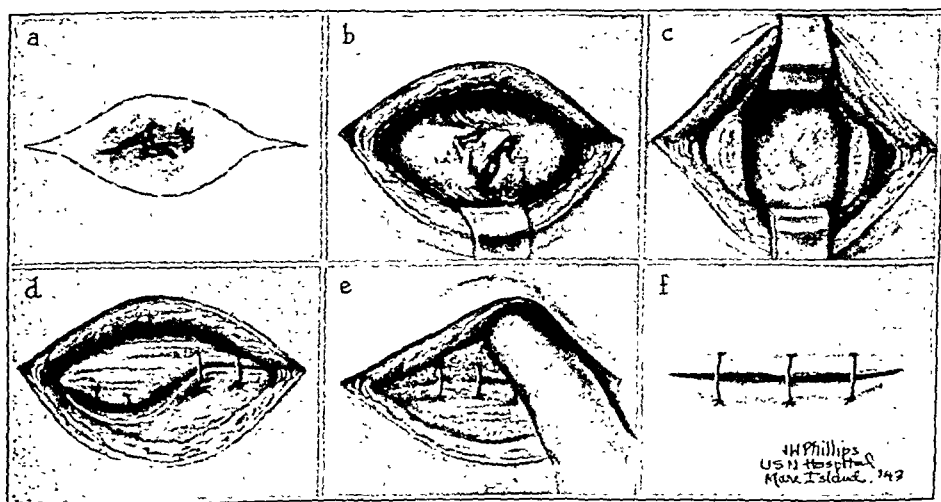


Fig. 8.—More extensive injuries to the thoracic wall involving the rib cage are treated by excision of traumatized skin, removal of unattached rib fragments, application of powdered sulfonamide drugs by smearing a suspension into all corners of the wound, overlapping of musculature to close the sucking wound and loose or no closure of the cutaneous wound.

may be resected and an aseptic end to end anastomosis performed with the Martzloff<sup>1</sup> modification of the Parker-Kerr technic.

**Clinical Considerations.**—Operation is best performed with the patient under some form of closed anesthesia, preferably given by the intratracheal route, which permits positive inflation of the lung when the thoracic wall is open. Suction for clearing bronchi is also highly desirable if not imperative.

1. Martzloff, K. H., and Burget, G. E.: Closed Intestinal Loop: Aseptic End-to-End Intestinal Anastomosis and Method for Making Closed Intestinal Loop Suitable for Physiologic Studies, *Arch. Surg.* 23: 26-37 (July) 1931.

trolled with suture ligatures. The pulmonary artery or any of its branches may be ligated with impunity, since nutrition of the lung is maintained through the bronchial artery and its branches ramifying through the bronchial wall. If the pulmonary vein requires ligation, the pulmonary artery should likewise be ligated to avoid active congestion of the lung. Both the pulmonary artery and the pulmonary veins from a lobe or a lung may be ligated without removing the lobe or the lung. A rent in the vena cava has been successfully sutured.

A laceration of the lung may require trimming with scissors of devitalized tissue (fig. 9), application of powdered sulfonamide drugs and

turing of the laceration with a continuous right-angled hemostatic lock stitch (fig. 10).

Partial resection of a lobe may be necessary in a mangled lung (fig. 11). A rubber-shod intestinal clamp or a hilar tourniquet, if available, may be applied across the hilus of the lobe for temporary control of bleeding. A second intestinal clamp is applied just proximal to the damaged lung. Before excision of the damaged lung, which may be used for retraction and drying of the lung, a continuous "cobbler's" stitch is applied proximal to the second clamp. A "cobbler's" stitch is one in which two needles which are full curved, round and noncutting are attached to the same suture, the two needles

to a point where no leakage occurs and the wound in the thoracic wall closed with the lung partially collapsed. Air may be aspirated five to seven days later. Sulfonamide drugs in powdered form are applied to all exposed pleural surfaces, to the raw pulmonary surface and along the suture line. If penicillin is available, its introduction into the pleural cavity followed by parenteral administration for several days is indicated in doses of not less than 100,000 units daily. In case of minimal damage to the lung

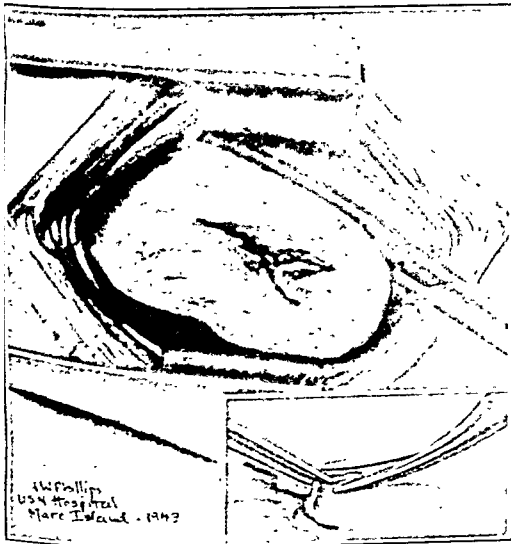


Fig. 9.—A laceration of the lung with moderate escape of air and blood may be excised and closed (fig. 10). The lung may be clamped proximally with rubber-shot intestinal clamps for temporary control of bleeding and escape of air. If escape of blood and air is easily controlled by deflating the lung, no sutures need to be applied. The chest is closed with the lung inflated and partial pneumothorax.

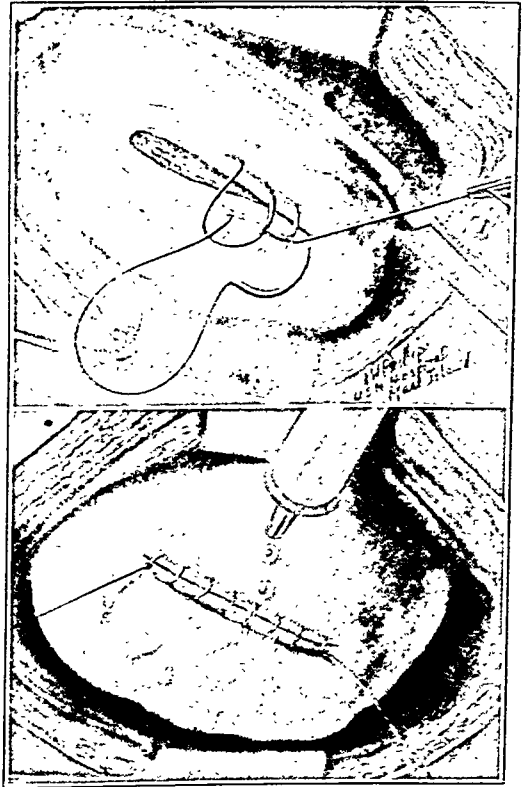


Fig. 10.—Closure of a laceration of the lung by a continuous right-angled, deeply applied suture of catgut on an atraumatic curved fine intestinal needle. After removal of the clamp and inflation of the lobe, the suture line is tested by dropping water on it. Leaks are reinforced with deeply placed interrupted sutures. If leakage of air is general from every stitch hole, the lung is collapsed to a semi-inflated state and the thorax is closed with partial pneumothorax, to be eliminated by aspiration several days later.

ing introduced back and forth through the lung proximal to the clamp, the suture being drawn tight each time and both vessels and bronchi thus being effectively closed (fig. 12). The damaged lung should be excised close to the clamp. The distal clamp is removed and the raw surface of the lung closed with an over and over stitch. These two sutures should be made with no. 0 chromic catgut on atraumatic needles, if available. The suture line is tested by inflating the lung and dropping water on it with a syringe. Bleeding points or leaking bronchi are controlled with individual reinforcing sutures. If air and blood escape from the suture line when the lung is fully expanded, the lung should be deflated

and slight contamination with foreign material, drainage is not necessary. When partial lobectomy is performed or when gross contamination with soil and clothing has occurred, a mushroom-tipped catheter is introduced in the intercostal space independent of the line of incision for air-tight drainage of the pleural cavity after closure of the wound (fig. 13).

If inspection of the lower portion of the thorax reveals a penetrating wound of the diaphragm,

the opening should be enlarged to permit exploration of the abdomen and underlying viscera. A roentgenogram taken previously will have established the location of the foreign body and possible injury to the viscera in line of its probable travel. Laparotomy is indicated in the presence of evidence of a perforated viscus that cannot be approached through the rent in the diaphragm. A large tear of or an injury to the liver must be drained to the outside with soft rubber tissue drains or packed if necessary to control bleeding, the drains and packing emerging through a separate stab wound in the abdominal wall below the diaphragm. Failure to drain a large hepatic wound is likely to result in fatal bile peritonitis. Bleeding from the liver may occasionally be controlled by applying a small piece of muscle held in place by a loosely tied suture.

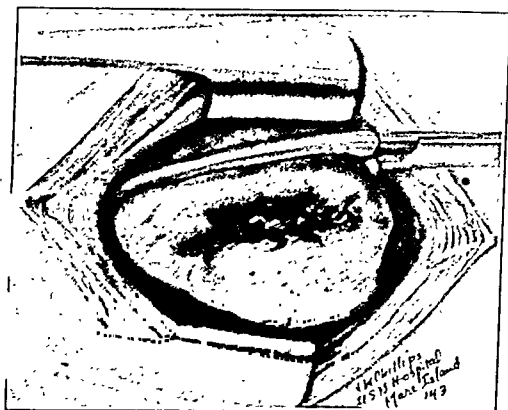


Fig. 11.—Localized mangling of a lung may require partial resection of the lobe (fig. 12).

On the left side a lacerated spleen may be removed through the diaphragmatic incision. Repair of a tear in the stomach or splenic flexure of the large bowel can also be effected through the diaphragmatic opening.

The rent in the diaphragm must be closed to avoid herniation of abdominal viscera into the chest, which is made imminent by the negative intrapleural pressure. A large wound in the left side of the diaphragm may permit herniation of the stomach, spleen or large bowel. Closure of the rent is easily effected when preceded by transpleural crushing of the phrenic nerve as it courses over the pericardium.

The defect in the thoracic wall producing the sucking wound must be closed, by approximation of muscle in layers if possible and of skin. To secure closure without tension it may be necessary to make semilunar incisions 5 to 6 cm. removed from the edge of the muscular defect, which will permit sliding of muscle over the de-

fect (fig. 14). If muscle or subcutaneous tissue is not available for closure of the defect, it will be necessary to slide skin flaps over the defect by a single or by two semilunar incisions

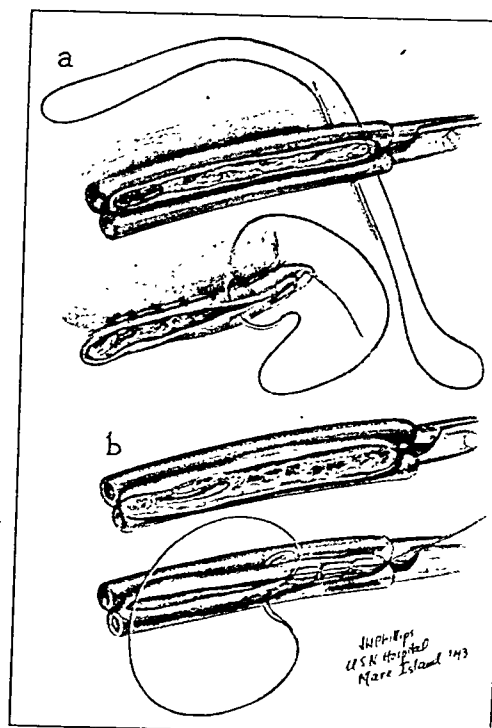


Fig. 12.—Two methods are available to close the surface of a lung after removal of traumatized tissue (a) a continuous cobbler's stitch applied with two needles on the same thread reinforced with a continuous over and over stitch or (b) a continuous right-angle lock stitch applied to the cuff of the lung lying beyond the clamp. Doubly threaded atraumatic curved fine intestinal needles may be used instead of straight needles.

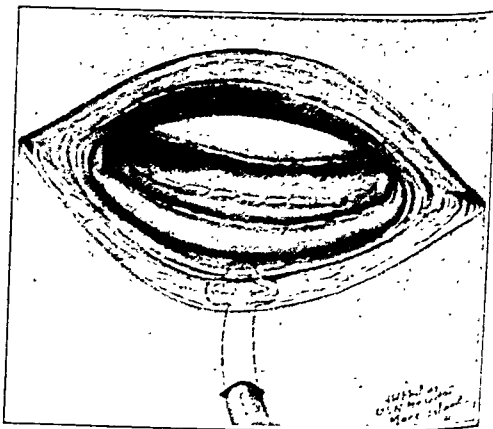


Fig. 13.—A mushroom-tipped catheter may be introduced into the thorax through an intercostal space independent of the incision for drainage following partial resection of the lobe or in the presence of gross contamination of the pleural cavity.

m. removed from the defect. The raw surface on the thoracic wall thus produced may be subsequently epithelized by skin grafting. The initial immediate necessity is closure of the sucking wound, with whatever viable tissues are available. Occasionally, a lower thoracic defect is best closed by utilizing the diaphragm and anchoring it to the parietal pleura above the defect. This is more easily done if the diaphragm is paralyzed by crushing the phrenic nerve transversally as it courses over the pericardium. After any closure of a large wound of the thoracic wall or closure of an exploratory incision, early complete expansion of the lung is usually highly desirable. To insure proper thoracic conditions for immediate reexpansion, closure of the thoracotomy is followed immediately by shifting the patient to his back and forming an aspiration of intrapleural air,

expulsive pain on deep breathing or on vigorous exercise. Moreover, a large foreign body known to the patient to be present is often a psychic hazard and may be held responsible in later life for symptoms originating elsewhere. Its mere presence may be an excuse for prolonged disability and justification for a pension. Hence the importance of removing large accessible foreign bodies, including those in the lung, when the hazard of operation is reduced to a minimum. Under ideal conditions for operation is obvious. Ideal conditions include facilities for accurate localization by fluoroscopy, availability of a fluoroscope in the operating room should it be necessary because of difficulty in locating the foreign body, an anesthetist trained and equipped to give closed anesthesia by the intratracheal route and a surgeon trained in thoracic surgery. Anesthesia administered by the intratracheal

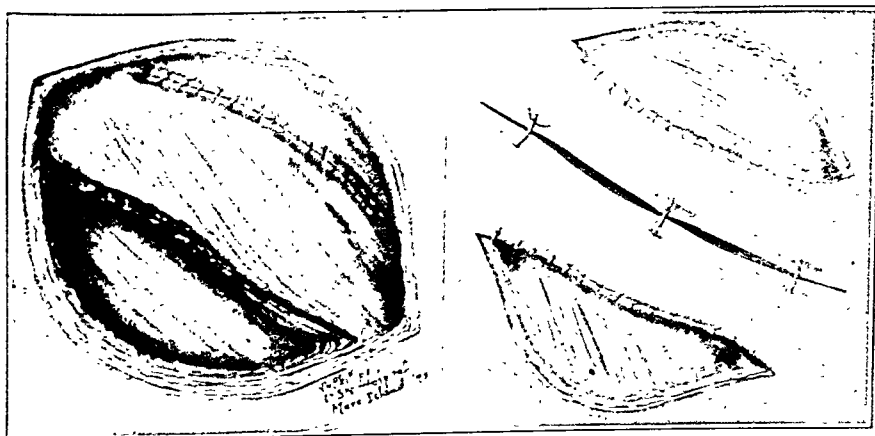


Fig. 14.—Closure of a sucking wound due to a defect in the thoracic wall may be effected by sliding muscle flaps which are mobilized by a semilunar incision either on one or on both sides, depending on tension necessary to approximate the edges over the defect. If muscle is unavailable, semilunar incisions in the skin also on one or both sides will permit closure of the defect. Subsequent epithelization of surface defects may be hastened by skin grafting.

preferably in the second or third interspace anteriorly, with a closed controllable system. If positive pressure is present and sustained, indicating leakage of air from the lung, the needle could be left in place and escape under water provided until air ceases to flow out. Rarely is it necessary longer than twenty-four to thirty-six hours.

A slight negative pressure is desirable and may be easily achieved by removal of a moderate amount of air.

#### 8. FOREIGN BODIES IN THE LUNG

*Clinical Considerations.*—In general, foreign bodies more than 1 cm. in diameter should be removed, whereas small fragments which cause no symptoms need not be removed. Large, jagged sharp fragments may migrate, owing to air weight, reach the pleural surface and cause

route permits expansion or collapse of the lung at will, and foreign bodies within the pulmonary substance are most easily felt with the lung collapsed. Moreover, a foreign body deep in the substance of the lung is most easily exposed with the lung collapsed. Two traction sutures are placed parallel to the proposed line of incision, and the lung is incised, no effort being made to control bleeding vessels or leaking bronchioles, except by digital pressure on each side of the incision. After removal of the foreign body, the cavity is gently curetted with a dull spoon or a curet to remove any clothing or other foreign material carried in with the metal fragment. A liberal amount of a powdered sulfonamide drug is placed in the cavity, and the rent in the lung is closed by first tying the retraction sutures and then applying a continuous right-



thoracotomy is usually performed in the eighth interspace in the posterolateral area (fig. 17). For limited exposure, as for the removal of foreign bodies which are easily accessible, the ribs need not be divided but can be spread sufficiently with a screw type of rib spreader. If more exposure is needed, the eighth and ninth ribs can be divided subperiosteally just lateral to the transverse processes underneath the erector spinae muscle. These muscles should not be divided but elevated, as they may be useful later in obtaining air-tight closure of the posterior extremity of the incision. The ribs are denuded of their periosteum for about 1.5 cm., and this denuded portion of the ribs is excised, to prevent subsequent pain from motion at the site of division of the rib. Additional exposure through this incision may be obtained by superiosteal division of the seventh rib at the same level. Closure of the wound in this area is affected by three circumcostal sutures of no. 2 chromic catgut doubled or of fine steel wire with approximation of the eighth and ninth ribs. The upper edge of the divided latissimus dorsi muscle is sutured to the inferior edge of the divided intercostal musculature with interrupted sutures of silk, and the lower edge of the latissimus dorsi muscle is sutured to the surface of this muscle above the wound; hence this second row of sutures overlaps the first line of sutures. Subcutaneous sutures of silk and a continuous suture of silk or steel in the skin complete the closure.

## 11. WOUNDS OF THE HEART (AFTER BECK)

*Practical Exercise.*—The heart of an anesthetized animal is exposed through an intercostal incision in the left upper portion of the chest. A catheter may be introduced into the pericardial sac and saline solution allowed to flow into the sac under controlled pressure to illustrate the effect of cardiac tamponade. The saline solution is withdrawn, and with an ice pick or a sharp scalpel a stab wound of the heart is produced, the pericardium is allowed to fill with blood until perceptible beating of the heart has ceased, the pericardium is opened, the confined blood is evacuated and the heart is massaged in a rhythmic manner if it is momentarily in asystole. The wound in the heart is sought for and the bleeding point controlled by digital pressure if it is in the ventricle. A rent in the auricle cannot be controlled by pressure but must be closed by grasping each edge separately with hemostats, drawing them together and approximating the edges with interrupted fine silk sutures. A traction suture of silk is applied to the apex of the heart for manipulation and steadying of the heart and for exposure of the posterior surface, should the wound involve that surface. With traction on

the apical suture and the wound in the heart still closed by digital pressure, sutures of silk on fine needles are applied on each side of the finger compressing the wound. The finger is withdrawn, and the sutures are crossed and held taut, while additional interrupted silk sutures are applied to the lips of the wound. Sutures must be applied parallel to and not across visible branches of the coronary artery. After complete control of bleeding is obtained, the apical suture is withdrawn and the pericardium incompletely closed with two or three interrupted widely spaced sutures, to permit escape of pericardial fluid or blood and thereby prevent postoperative cardiac tamponade.

*Clinical Considerations.*—Increased intrapericardial pressure, namely, cardiac tamponade, requires prompt relief to avoid death. When a single thoracic wound of entrance is present without a wound of exit or when the heart and the pericardium lie in the path of a through and through penetrating wound, the following symptoms should suggest cardiac tamponade: extreme pallor and/or cyanosis, extreme shortness of breath, weak rapid pulse, that becomes imperceptible, weak heart sounds, absence of the apex beat and a gradually decreasing blood pressure, decreasing pulse pressure and increasing venous pressure, as disclosed by distention of the veins of the neck or by actual measurement. These presenting symptoms may vary greatly in intensity and in rapidity of development, and some even may be absent until just before death.

A pericardium full of fluid or blood may be aspirated by introducing a long needle to the left of the midline just under the left costal margin, the needle being directed toward the middle of the left clavicle. If methods for relieving pressure or obtaining blood are unsuccessful when cardiac tamponade is suspected, exposure of the heart is necessary.

A longitudinal incision slightly curved at its lower end is made, practically paralleling the left sternal border and permitting excision of the fifth costal cartilage, the fourth costal cartilage, part of the fourth rib and the third costal cartilage. Division of the triangularis sterni muscle and deflection of the left pleura laterally reveal the pericardium. The wound already present is extended or the pericardium is incised longitudinally between two stay sutures of silk. The blood clots are emptied out, and the procedures as described in the preceding experiment, with closure of the bleeding wound, are carried out.

After loose closure of the pericardium, the left pleura is opened so that any pericardial fluid or blood may leak into the left pleural cavity, where it may more readily be absorbed or from which it may easily be aspirated if necessary.

No drainage with a rubber tube or a tissue drain is indicated except in the presence of gross pus. When aspiration of the pericardium, as described previously, has revealed the presence of pus, the incision is greatly limited, and excision of one costal cartilage at the level of the sixth rib anteriorly is sufficient.

## 12. GUNSHOT WOUNDS OF THE CHEST

*Practical Exercise.*—The final exercise consists in placing an anesthetized animal upright

against some heavy sand bags and shooting it through the chest with a revolver at a distance of about 5 feet (1.5 meters). The damage inflicted is then repaired according to the principles laid down in the previous exercises.

The animal is always killed at the end of the exercise, but it is surprising how often complete repair of the wounded organs is possible, and it is probable that in many of these instances the dog would survive if it were allowed to.

# PARALYSIS OF THE LARYNX

AN EARLY SIGN OF RECURRENCE FOLLOWING RADICAL MASTECTOMY  
FOR CARCINOMA, WITH A REPORT OF SIX CASES

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PHILADELPHIA

In this era of surgical treatment of cancer it is not necessary to reemphasize the importance of early recognition of the disease. This applies not only to the initial diagnosis but to the postoperative follow-up visits, when the patient is carefully examined for evidence of a recurring lesion. The following 6 cases of surgically treated cancer of the breast point out a helpful clinical observation to aid in the early recognition of recurrence.

When hoarseness occurs following mastectomy for carcinoma of the breast the possibility of metastasis must be considered. In each of the cases presented in this group there was a period following mastectomy during which the patient enjoyed complete symptomatic freedom from disease. This period varied from fourteen months to twelve years. The patient's well-being was then suddenly interrupted by changes in the voice, described as persistent hoarseness or huskiness. There were also intermittent weakness of the voice, a tendency for the voice to crack and a nonproductive cough, unaccompanied by any evidence of infection of the respiratory tract. Dyspnea was severe in 1 patient and was experienced on exertion by the others. In each instance, however, it was the laryngeal disturbance which caused the patient to consult her physician.

With curiosity directed toward the larynx, an effort was promptly made to determine the cause of the hoarseness. The most important diagnostic procedure was inspection of the larynx. This was accomplished by indirect, or mirror, laryngoscopy, a relatively simple procedure, which requires a laryngeal mirror and an adequate source of illumination. Visualization of the larynx revealed the cause for the hoarseness to be fixation of one or both vocal cords. This failure of movement of a vocal cord accompanied by loss of tension or relaxation characterized the paralysis of the recurrent laryngeal nerve on the affected side. In seeking the reason why a recurrent laryngeal nerve should suddenly cease to function in these cases one is struck by the impor-

tance of metastatic recurrence of mammary cancer.

Part of the drainage of lymph from the breast has been satisfactorily traced to the chain of nodes surrounding the recurrent laryngeal nerve. Metastasis, therefore, may be from a cancerous breast on the same or on the opposite side. The three generally accepted lymphatic pathways of homolateral drainage are<sup>1</sup>:

1. From the mamma to the axillary nodes, to the supraclavicular group and to the thorax via the chain of nodes surrounding the recurrent laryngeal nerve.

2. From the mamma directly to the subclavian nodes and to the infraclavicular plexus. This plexus empties into the junction of the internal jugular and subclavian veins but gives off some efferent vessels to the supraclavicular nodes, which in turn are linked to the chain of nodes around the recurrent laryngeal nerve.

3. From the mamma, perforating the pectoralis major, pectoralis minor and intercostal muscles, to the internal mammary chain. This pathway terminates in the venous circulation at the root of the neck. Some aberrant efferent vessels pass over the clavicle and drain directly into the supraclavicular nodes and thence proceed to the chain in the region of the recurrent laryngeal nerve.

Contralateral involvement, interestingly, is not the exception, since it occurs with almost the same frequency as paralysis of the same side.<sup>2</sup> Contralateral spread occurs from the cutaneous lymphatics overlying the periphery of the mammary structure and from the lymphatics near the inner periphery of the mamma. Both of these pathways terminate in the axillary and supraclavicular groups of nodes of the opposite side. From these routes it may be concluded that the most likely seat of metastasis is in the supra-

1. Turner, A. L.: Paralysis of the Vocal Cord Secondary to Malignant Tumor of the Mamma, *J. Laryng. & Otol.* 36:373, 1921.

2. Turner, A. L.: Abductor Paralysis of the Right Vocal Cord Subsequent to Scirrhus Cancer of the Left Mamma, *J. Laryng. & Otol.* 40:534, 1925.

From the Department of Laryngology, Jefferson Medical College Hospital.

clavicular and/or the internal mammary group. Since both these groups drain into the lymph nodes surrounding the recurrent laryngeal nerve, paralysis of a vocal cord gives early warning that all is not well.

The following 6 case histories are from the department of laryngology of the Jefferson Medical College Hospital.

#### REPORT OF CASES

**CASE 1.**—E. M., a 41 year old white woman, was well for eighteen months following radical mastectomy for carcinoma of the right breast. The patient suddenly acquired hoarseness, followed by a nonproductive cough. There was no dyspnea; but a constant feeling of fatigue, with a loss of 10 pounds (4.5 Kg.) in two months, was described. Laryngeal examination revealed left-sided paralysis with the vocal cord in the cadaveric position. The tension was poor. The right side of the larynx showed no changes. Roentgen study of the chest revealed a dense shadow at the root of the left lung.

The diagnosis was paralysis of the left recurrent nerve and metastatic carcinoma of the hilar area of the left lung.

**CASE 2.**—B. W., a 45 year old white woman, remained free of symptoms for two years following radical mastectomy for carcinoma of the right breast. A tired feeling in the throat with progressive weakening of the voice began two weeks before hoarseness developed. When changes in the voice did not improve, the patient presented herself for examination, six weeks after the onset. The larynx showed complete paralysis of the left side with the left vocal cord in the cadaveric position. The right side of the larynx was normal. A firm mass was palpable in the left supraclavicular area. Endoscopic examination of the larynx and hypopharynx did not yield any additional information. Roentgen study of the chest failed to reveal any metastasis.

The diagnosis was paralysis of the left recurrent nerve and metastatic carcinoma of the supraclavicular cervical lymph nodes.

**CASE 3.**—T. S., a 44 year old white woman, had a radical mastectomy of the left breast for scirrhous adenocarcinoma. After twelve years of good health the patient suddenly began to suffer from hoarseness with some dyspnea, notably on exertion, and examination of the larynx revealed bilateral paralysis of the larynx with both vocal cords in the midline. Three days after the onset of dyspnea, it was necessary to do a tracheotomy. The patient died of respiratory embarrassment two days later. Postmortem examination revealed metastatic scirrhous adenocarcinoma of the mediastinal structures, lymph nodes and great vessels of the neck and lungs and also metastatic carcinoma of the lateral nucleus of the thalamus. Severe compression of the trachea below the site of the tracheotomy tube was present.

The diagnosis was paralysis of the recurrent laryngeal nerve of both vocal cords and metastatic scirrhous adenocarcinoma of the mediastinum and the lateral nucleus of the thalamus.

**CASE 4.**—C. R., a 47 year old white woman, submitted to radical mastectomy of the right breast for scirrhous adenocarcinoma. Fourteen months later she suddenly noticed hoarseness and a nonproductive cough. One month later, when changes in the voice persisted, she presented herself for examination. Laryngeal examination revealed the left vocal cord fixed in the midline with good tension. No other laryngeal changes were present. One month later paralysis of the left cervical sympathetic nerves occurred, resulting in Horner's syndrome. The left vocal cord then had assumed the cadaveric position. A firm, nontender mass was palpable in the left supraclavicular area.

The diagnosis was paralysis of the left recurrent laryngeal nerve and metastatic carcinoma of the cervical lymph nodes.

**CASE 5.**—F. P., a 42 year old white woman, underwent radical mastectomy for adenocarcinoma of the right breast. Two years and three months later hoarseness suddenly developed, with no accompanying evidence of an infection of the respiratory tract. A hard, nontender mass was palpable in the right supraclavicular area. The larynx showed fixation of the right vocal cord in the midline with good tension. There was some difficulty in swallowing. Biopsy of the lymph nodes which were adherent to the right carotid sheath and involved the right recurrent laryngeal nerve revealed metastatic adenocarcinoma. Three weeks after biopsy the larynx had not shown any improvement.

The diagnosis was paralysis of the right recurrent laryngeal nerve and metastatic carcinoma of the cervical lymph nodes.

**CASE 6.**—M. C., a 55 year old white woman, had a radical mastectomy for adenocarcinoma of the left breast. After two years of good health the patient suddenly became hoarse. Examination of the larynx revealed complete paralysis of the left side of the larynx with the left vocal cord in the cadaveric position. Subsequently supraclavicular lymphadenopathy on the left side and Horner's syndrome developed. She died of carcinomatosis six months later.

The diagnosis was paralysis of the left recurrent laryngeal nerve and carcinomatosis.

#### SUMMARY

Hoarseness occurring after radical mastectomy for carcinoma of the breast is often the first clinical evidence of metastasis.

Metastasis from carcinoma of the breast causes paralysis of the recurrent laryngeal nerve on the same or on the opposite side by involving the chain of lymph nodes surrounding the recurrent laryngeal nerve.

The group of cases of pyogenic renal infection comprises 38 cases of pyelitis and 5 of pyelonephritis. In 11 cases of pyelitis the infecting organism was *Staphylococcus aureus*; in 22, *Bacillus coli*; in 1, *Bacillus alkaligenes*, and in 1, *Bacillus mucosus capsulatus*. In 14 cases the infection was bilateral. Twenty-four patients were cured entirely of their infection, 8 were improved, 2 were unimproved and 4 were seen only once or twice. A few of these patients were treated with sulfonamide compounds.

There were only 5 patients with pyelonephritis. Two had bilateral infections with moderate elevation of systolic blood pressure. Two were treated by nephrectomy, 1 of whom recovered and the other of whom died in three years. The other 3 improved, but the infections never subsided completely.

Hydronephrosis in early adulthood is a comparatively common condition of men. It occurred in 29 cases (8.8 per cent) in this series. Eight patients had bilateral lesions. Sixteen patients had symptoms of less than one year's duration, while 1 had had periodic symptoms for twenty-six years. Only 2 had slight elevation of blood pressure. Eight were treated by nephrectomy and 12 by various plastic procedures on the ureteropelvic junction and nephropexy. Four were treated by dilation of the ureter.

Trauma of the kidney occurred as frequently as hydronephrosis. Twenty-three of the 29 patients were in their early twenties. Most of them were injured in automobile accidents or while playing football. Twenty-four recovered with expectant treatment. Five had nephrectomy. In 5 cases infections of the injured kidney developed. In 1 case the infecting organism was *B. coli* and in 4 it was *Staph. aureus*. There were no deaths. In most cases cystoscopy was performed when the kidney was healed. The pelvis apparently healed completely. However, the function of two of the healed kidneys was diminished, as indicated by the functional phenosulfonphthalein test. All infections were controlled.

Tuberculosis of the kidney occurred in 21 cases. In 3 instances one parent had died of tuberculosis. Bilateral renal disease was present in 5 cases. Fourteen, or two thirds, of the patients were less than 25 years of age. Only 3 had symptoms dating back to the eighteenth year or earlier. Thirteen patients were treated by nephrectomy and partial ureterectomy, 10 on the right side and 3 on the left. The results show that 12 patients are apparently well. Three are living but have tuberculosis; 5 have moved away and their present condition is not known, and there has been 1 death.

Hematuria of unexplained origin occurred in 12 cases. Thorough investigative measures were employed and repeated without determining the etiologic factor. None of the patients passed stones or had an infection of any kind in the urinary tract. The duration of their hematuria ranged from three days to two years.

Anomalies of the kidneys were infrequent—more infrequent than those of the kidneys of the average group of patients examined.

Ptosis of the kidney is rare among men. Five of the 6 patients who had nephroptosis were past 30 years of age. The symptoms of pain in the kidney lasted from three weeks to ten years. Only 1 patient had surgical nephropexy.

A diagnosis of phosphaturia was made in 4 cases. In these cases the duration of symptoms of urinary irritation and frequency with a small vesical capacity extended from five days to twelve years, with visits to many physicians without relief. None of the patients had infections of the urinary tract or calculi demonstrable by cystoscopic and roentgenologic examinations. In 3 cases the condition was controlled by ingestion of dilute hydrochloric acid, while in the fourth there was not much improvement after two months of treatment.

Nephrosis as such occurred in 3 cases. In 1 case there was a familial history of cardiorenal disease. In the other 2 there were histories of prolonged symptoms of seven years or more. Albuminuria, low specific gravity of the urine, diminished renal function and elevated blood pressure were present. The patients were all treated in a conservative manner, without any appreciable improvement.

Renal tumor occurred in only 1 case.

The peak of adult renal health undoubtedly occurs before the fortieth year. Thirty-one, or almost 10 per cent, of the patients had either a familial factor of renal disease or symptoms of renal disease before the age of 18 years.

#### URETER

*Anomaly.*—Wilson and Herzlich<sup>18</sup> report a case of postcaval ureter. Medical literature contains reports of only 27 cases. These include cases found at necropsy as well as at operation. Of all cases recorded, in only 1 has the condition been diagnosed preoperatively. Cases of right postcaval ureter as well as of bilateral postcaval ureter have been observed. In the latter condition there is a double vena cava with each ureter passing behind its respective vein. The present opinion unanimously ascribes the fault to the embryonal vascular system rather than to the

18. Wilson, C. L., and Herzlich, J.: Post Caval Ureter. *J. Urol.* 51:14-18 (Jan.) 1944.

urinary system; for this reason the anomaly has not been classed with ureteral abnormalities. From the clinical standpoint, however, it may well be placed in the latter group.

Wilson and Herzlich's patient complained of typical renal colic on the right side. The symptoms had begun about six months prior to admission to the hospital, at which time the patient noted intermittent attacks of pain in his right loin. Retrograde pyelograms revealed an essentially normal left kidney and ureter. The right kidney was found to be severely hydronephrotic. At operation the renal pelvis was identified and was traced downward. The upper portion of the ureter was dilated to  $3/4$  inch (2 cm.) in its widest diameter. This was traced down for a distance of approximately 3 inches (8 cm.), at which point it was noted that the ureter passed medially and crossed beneath the inferior vena cava. It could be demonstrated definitely that the ureter passed completely beneath the vein and that the portion beneath the vein was of normal size but was compressed. The ureter below this level was normal in size and appearance. The ureter was ligated and divided approximately 1 cm. lateral to the vena cava. The renal pedicle was exposed and was found to be extremely short. The pedicle was doubly clamped, ligated and divided, and the kidney was removed.

*Transplantation.*—Stevens and Marshall<sup>19</sup> discuss reimplantation of the ureter into the bladder. The need for the operation is apparently most frequent after vesical resection for neoplasms involving a ureteral orifice, but reimplantation will be employed in the occasional case of accidental injury to a ureter, of obstruction of the lower part of the ureter due to intrinsic or neighboring disease or to diverticulum of the ureter or the bladder. The methods employed for reimplantation of the ureter into the bladder may be divided into two groups—with the ureter (1) running directly into the lumen of the bladder through a stab wound or (2) entering obliquely according to nature's usual rule governing the entrance of conducting tubes into cavities. Sutures are sometimes placed outside the bladder, through the ureteral and vesical walls; sometimes they are used only within the bladder, or they may be placed both inside and outside the bladder. Within the bladder, the end of the ureter may be slit on one side only, to make a long elliptic opening, and the end fastened to the vesical mucosa and submucosa only or by pene-

trating sutures to the whole thickness of the vesical wall. Or the distal centimeter of the ureter may be split in two and each flap secured to the bladder.

Realizing that obstruction is a large factor in vitiating results and that infection also plays a major role, Stevens and Marshall have been trying a simple technic during the past three and a half years. The operation is always carried out extraperitoneally. To diminish formation of fibrous tissue drains are so placed that only rubber tissue is in contact with the tissues and the drains are removed early. Tension is avoided. Sutures are used only inside the bladder and penetrate mucosa and submucosa only, and the bladder is kept at rest by suprapubic drainage. Fine chromic sutures—no. 0000—are used. No deleterious results have been noticed from having the knots within the bladder. Sulfadiazine is used to control infection. In 2 cases, one suture was used outside the bladder, placed in the peri-ureteral tissue, but otherwise none was employed.

A small incision is made at the appropriate place on the vesical wall, penetrating muscle only. A rather pointed curved clamp bluntly dissects a channel under the mucosa downward toward the vesical outlet for about 2 cm. A small incision is made through the mucosa over the end of the clamp. Working through a suprapubic vesical opening, another clamp is passed retrograde through this channel and grasps the ureter, the distal centimeter of which has been bisected, to form a "fish-mouth." The ureter is drawn into the bladder through this channel, and the two ends are each fastened to the vesical mucosa and the submucosal tissues.

Reports of data on 10 patients are given. Nine of the patients had carcinoma of the bladder, and 1 had low fibrous ureteral obstruction. Urograms made before and after operation demonstrate little or no dilatation of the upper part of the urinary tract after operation in 5 cases in which the urograms had been normal before operation. Ureters dilated before operation have remained so afterward. Increased ureteral dilatation, as noted in the late postoperative pyelogram, was seen but once. In that instance the patient probably had local recurrence of carcinoma. There were no perivesical abscesses or fistulas.

In all cases function of the kidney on the side on which the operation was performed, as demonstrated in the five minute films of the excretory urogram series, was as good after operation as before, or better.

In 2 of 4 cases in which cystograms were taken postoperatively there was no ureteral reflux

19. Stevens, A. R., and Marshall, V. F.: Reimplantation of the Ureter into the Bladder: Report of a Method Applied to Ten Patients, *Surg., Gynec. & Obst.* 77:585-594 (Dec.) 1943.

some months' after operation; there was slight reflux eight months after operation in 1 case in which the ureter had been dilated and thickened above a fibrous obstruction, and there was definite reflux a few weeks after operation in the fourth case.

Higgins<sup>20</sup> reviews 19 cases of transplantation of the ureters into the rectosigmoid of infants.

Exstrophy of the bladder is classified into four types as follows: (1) fissura vesicae superior, in which there is a normal union of the pubis but a defect in the upper part of the bladder; (2) fissura vesicae inferior, in which the symphysis is developed normally but the bladder is split inferiorly; (3) typical complete exstrophy, in which the symphysis pubis is absent with varying degrees of separation of the pubic bones; (4) exstrophy of the bladder complicated by intestinal openings on the extroverted area.

In the third type the everted bladder protrudes above the level of the surrounding abdominal wall. In male patients, epispadias is always present. The prostate may be absent, or cryptorchism may occur. At times a bifid scrotum may be observed. In the female patients the clitoris is cleft, the labia are rudimentary and the urethra forms an open sulcus. A double vagina or a bicornate uterus may also be present.

The age for transplanting the ureters into the rectosigmoid for the relief of children suffering from exstrophy of the bladder merits serious consideration. Without surgical intervention 50 per cent of the children die before the age of 10 years and 66 per cent succumb before the age of 20 years. In the majority of instances renal sepsis and renal failure are directly responsible for early death. It is usually advocated that operation be postponed until the child is 4 to 6 years of age and until he has gained control of the rectal sphincter.

This recommendation ignores the fact that children less than 5 or 6 years of age experience repeated attacks of pyelitis or pyelonephritis and that in many instances death occurs before the child has attained 4 or 5 years of age. Obstruction frequently develops at the ureterocystic junction on the exposed bladder, producing hydro-ureter and hydronephrosis, which not only may be conducive to infection of the upper part of the urinary tract and destruction of renal parenchyma but may render transplantation of the ureters into the bowel technically impossible or in some instances may necessitate removal of one kidney. Thus ureterocystic obstruction may produce

stasis, followed by infection, renal sepsis and impairment of renal function, resulting in death of the child during the first two or three years of life unless surgical intervention is undertaken.

In view of results secured during the last three or four years, Higgins believes that the operation should be performed on infants during the first year of life, preferably during the first six months for the following reasons: 1. Just as the infant tolerates the trauma of passing through the birth canal, it tolerates surgical procedures extremely well. As is attested by the results in other fields of surgery, delay is not countenanced; plastic operations for harelip, the Rammstedt operation for pyloric obstruction, operative intervention for intussusception or strangulated hernia and other surgical procedures are performed without hesitation. 2. Recurrent attacks of renal infection may result in sepsis and death before the child is 4 to 6 years of age. 3. The organisms in the bowel of infants less than 6 months of age probably are less virulent than those in older children and in adults. 4. Because of ureterocystic obstruction, the ureter may dilate sufficiently to render its transplantation into the bowel technically impossible. Although one ureter may be transplanted, hydronephrosis on the opposite side may require removal of the kidney. 5. If the operation is performed early in life, the child may develop normally both physically and mentally. 6. The operative mortality rate and the morbidity rate are low. 7. The tone of the rectal sphincter, in Higgins' experience, has always been adequate to prevent leakage of urine from the rectum after the sphincter starts to function normally. 8. Because of the parents' attachment to the child, it is better that if death should result from operation it should occur before ties are established.

The purposes of the preoperative routine are to cleanse the bowel completely of fecal contents and to sterilize the bowel as far as possible.

The operation is performed while the child is under ether anesthesia. Higgins does not recommend the simultaneous transplantation of the ureters into the rectosigmoid of infants less than 1 year of age. Transplantation of the right ureter should be done first, followed in ten days by transplantation of the left ureter into the bowel. The exstrophic bladder may be removed at this time. The plastic operation to correct the epispadias should be delayed until the child is 5 or 6 years of age. Technically, transplantation of the ureter into the bowel is more difficult in an infant than in an adult. The diameter of the ureter of an infant is considerably less than the diameter of the ureter of an adult, and the muscularis layer of the rectosigmoid is thin. The

20. Higgins, C. C.: Transplantation of the Ureters into the Rectosigmoid in Infants: Review of Nineteen Cases, *J. Urol.* 50:657-666 (Dec.) 1943.

serosal and muscularis layers must be incised with great care down to the mucosa, therefore, to form the trough in the intestinal wall to be occupied by the ureter. A modification of the Coffey technic is used. To prevent undue tension on the ureter with consequent kinking and angulation, the anastomosis must not be too tight. The operation in reality is a plastic procedure. It is Higgins' opinion that postoperative dilatation and hydronephrosis are due to technical errors and can be avoided.

Administration of  $\frac{1}{4}$  to  $\frac{1}{2}$  fluidrachm (0.9 to 1.8 cc.) of camphorated tincture of opium U.S.P., according to age, is continued for one day after operation. The rectal tube inserted at operation is kept in place seven to ten days and may be irrigated gently at intervals to maintain its patency.

In this series of 19 cases of exstrophy of the bladder in which the ureters were transplanted into the rectosigmoid before the patient was 1 year of age, complications were negligible and the postoperative course was smoother than that for older children. In 1 case the wound disrupted on the sixth postoperative day. This complication is now avoided by using silver wire to close the abdomen. In 2 cases, after transplantation of one ureter into the rectosigmoid and cystectomy, nephroureterectomy was performed on the opposite side because of the presence of a large dilated ureter and infected hydronephrosis. The causative factor was obstruction at the uretero-cystic junction.

Two of the infants died after operation.

Lower,<sup>21</sup> in discussing late results after transplantation of the ureters into the rectosigmoid, states that for the immediate future patients can be promised definitely that the risk of operation is greatly reduced, because the occurrence of peritonitis, which was rather common in earlier operations, is now practically eliminated. Until a sufficiently large series of cases has been followed over a long enough time, it cannot be stated what the social and economic status of the patient will be years later. Lower reports a series of cases which has been followed for more than twenty years. Out of 80 patients whose ureters were transplanted for conditions other than malignant lesions, 6 patients have survived for more than 20 years.

As Lower is now operating for this condition while the patient is still an infant, there is a relatively better chance of following these patients for a longer period than those on whom oper-

ation was performed when they were adults. Since 1932, when Lower first transplanted the ureters of a child 5 months old, he has advised the operation on infants.

He has included in this series of 80 cases only those in which operation was performed for exstrophy of the bladder, vesicovaginal fistula and Hunner ulcer, in other words, those cases in which urinary incontinence could not be corrected in any other way.

After trying out various technics, Lower has reduced the operation to the simplest possible form by using only absorbable ligatures and no mechanical aids whatsoever. There are certain points which should be emphasized. The first point, of course, is the careful preoperative preparation of the bowel. Adults receive a nonresidue liquid diet. One ounce (31 Gm.) of magnesium sulfate in 8 fluidounces (240 cc.) of water is given every morning daily in doses of 1 fluidounce (30 cc.) every fifteen minutes until the 8 fluidounces has been taken. The patient receives a daily cleansing enema. The day before operation no magnesium sulfate is given but cleansing enemas are ordered as frequently as necessary to cleanse the bowel completely of any fecal material. Ten minims (0.6 cc.) of tincture of opium is given three times on that day. The preoperative preparation should take between four and five days for complete emptying of the intestinal contents. In addition 1 Gm. of sulfasuxidine (succinylsulfathiazole) every four hours, four doses daily, for four days is given preoperatively. By this means, a double purpose is accomplished: first, a mechanical cleansing of the bowel and, second, an attempt at sterilization of the bowel.

If the patient is an infant, daily cleansing enemas are given but no magnesium sulfate is used. The diet consists of whole milk or milk formula, and no vegetables or cereals are allowed. The preoperative preparation lasts for three or four days. On the day preceding operation, dextrose water and water are substituted for the milk. Similarly, on the day before operation as many enemas are given as are necessary to obtain a clear return from the colon. On this day also from  $\frac{1}{4}$  to  $\frac{1}{2}$  fluidrachm (0.9 to 1.8 cc.) of camphorated tincture of opium U.S.P. is given three times, the dose depending on the age of the infant. Sulfasuxidine is given in amounts which also depend on the age and the weight of the child.

Secondly, one must be especially careful to avoid angulation or constriction where the ureter is brought out from behind the peritoneum and is first attached to the bowel. In cases in which the ureter is transplanted for

21. Lower, W. E.: Late Results Following Transplantation of the Ureters into the Rectosigmoid, *J. Urol.* 50:581-584 (Nov.) 1943.



a shorter distance the patients seem to do better than in those cases in which the trough is too long and too much ureter is transplanted.

If the patient is an adult, unless there is a contraindication, Lower prefers to use spinal anesthesia, as it relaxes the abdominal muscles more completely than inhalation anesthesia, but if the patient is an infant he generally gives ether. In a number of cases both ureters have been transplanted at one procedure; this, he believes, is without any particular risk, especially for adults, unless there is some condition which might prolong the operation.

Of the series of 80 cases, data on 6 cases are presented in which the ureters were transplanted into the rectosigmoid more than twenty years ago; 3 patients are married, and none has been divorced. Their social and economic status has been restored.

Stevens and Lord<sup>22</sup> carried out a modification of Coffey I technic of ureterointestinal anastomosis in the dog by means of a vitallium tube inserted into the end of the ureter. They draw the following conclusions:

Suggestive evidence has been presented that the theoretical obstruction to urinary outflow caused by edema of the anastomosis is not the sole basis for the postoperative rise in the blood urea nitrogen. Improvement in the late results of ureterointestinal anastomosis of the Coffey I method by means of a vitallium tube was not obtained. Vitallium tubes in constant contact with urine and the bacterial flora of the sigmoid usually became calcified in 3-4 weeks.

*Calculi.*—Ainsworth-Davis<sup>23</sup> reports data on 20 cases of ureteral stone. He states that a large percentage of the smaller renal calculi, once they enter the ureter, will pass naturally without operative or instrumental intervention, though a number become impacted in either the upper or the lower portion of the canal. Those in the upper part should be removed by ureterolithotomy if they give rise to back pressure symptoms of renal pain or to signs of dilatation of the renal pelvis and calices, as shown by intravenous pyelography. When the stone, however, is held up in the lower part of the ureter, instrumentation should be given a trial before resort is made to operative measures. If the stone is actually in the intramural portion, it is usually a simple matter to insure its passage into the bladder within twenty-four to forty-eight hours by cutting the anterior ureteral wall overlying the calculus with a ureteral meatotome.

22. Stevens, A. R., and Lord, J. W., Jr.: The Experimental Use of Vitallium Tubes in Ureterointestinal Anastomosis, *J. Urol.* **50**:574-579 (Nov.) 1943.

23. Ainsworth-Davis, J. C.: Calculi Impacted in the Lower Fourth of the Ureter: Their Removal by the Ureteric Corkscrew, *Brit. J. Surg.* **31**:34-38 (July) 1943.

The patient is placed in the lithotomy position on a salt plate which is connected with the terminal of the diathermy machine. The cystoscope is passed, the obturator is withdrawn from the telescope, with a single catheterizing instrument and a meatotome, is inserted. After the latter has been connected to the other terminal of the diathermy machine, a survey of the bladder is made and the tip of the meatotome is inserted into the obstructed ureter for a distance of 1.5 cm., great care being taken that the aperture of the diathermy knife is facing up and inward, toward the cavity of the bladder. The knife is next made to present, by pressing the knob at the proximal end of the electrode, when a tentlike fold of anterior ureteral wall can be seen to be elevated, and with a touch of the foot switch the tip of the knife will emerge from the bladder. With the current on, gentle traction of the cystoscope will cause complete division of the wall of the ureter as far as its orifice, whereupon the knife is sheathed by pulling the handle of the meatotome, and the meatotome is withdrawn. When using the corkscrew method, Ainsworth-Davis inserts the corkscrew past the stone by rotary motion and exerts traction. Traction can be continued for some time by means of a device of weights.

This method has been used on 20 patients; in all cases the stone was impacted in the lower part of the ureter. In most cases the stone passed within several hours to three weeks after manipulation. In 1 case it was necessary to remove the stone by operation.

Wishard<sup>24</sup> states that three courses are considered in the treatment of stones in the lower part of the ureter: 1. Spontaneous passage under observation is prudent in the face of prognosis if the stone is not too large, if the time required is not too long and if the patient is not suffering from too severe ureteral obstruction with attendant stasis and infection. 2. Instrumental passage is safe if coincidental ureteral drain and dilatation are maintained and if extraction is accomplished with flexible nonmetallic instruments. Instrumental passage should be abandoned in favor of surgical removal if progress ceases or if drainage becomes ineffectual; there is danger of attendant sepsis. The use of metallic extractors introduces hazards, which Wishard discusses. 3. Surgical removal should be used for stones which are disproportionately too large to pass or extract, or if it seems wise to abandon method 1 or 2. Surgical removal is safe and for the most part certain and final.

24. Wishard, W. N., Jr.: Stone in the Lower Third of the Ureter with Report of an Instance of an Incarcerated Basket, *J. Urol.* **50**:775-783 (Dec.) 1943.

from the complications of method 2. In eighteen years Wishard has not had any deaths among private patients suffering from ureterolithiasis. An instance is reported illustrating failure with the extraction method, fracture of the basket and delivery of stone and basket from above.

Balkus<sup>25</sup> describes the use of a looped catheter in the treatment of ureteral calculi.

The materials required are a ureteral catheter, a strand of steel surgical suture wire (no. 33 or no. 35) approximately 6 inches (15 cm.) longer than twice the length of the catheter to be used and an ordinary pin. Since the catheter is employed usually in the attempt to extract stones from the pelvic segment of the ureter, it may be shortened to any desired length by removing a segment from its proximal end. This is desirable since less wire and effort are required to modify the shortened catheter. The latter should be whistle tipped and either no. 4 or no. 5 F., a no. 4 F. catheter being preferable, since it is easier to introduce and less likely to inflict injury.

With the exposed portion of the wire closely applied to the body of the modified catheter, the latter is passed into the ureter and to a point approximately 10 cm. beyond the level of the stone. Ureteral meatotomy has not been necessary in any of the cases, since the loop insures adequate dilatation. A small amount of liquid petrolatum is injected, after which the loop is formed by traction on the free end of the wire. The looped catheter then is withdrawn slowly. At the same time the ureteral orifice is kept under observation. As the stone held in the grasp of the loop enters the intramural segment of the ureter, bulging is noted, and at this time the beginning of the loop may be seen projecting through the ureteral orifice. The cystoscope may or may not be removed at this time. There is comparatively little danger of inflicting serious injury at this stage of the procedure, so that considerable traction may be applied. It is important to maintain the loop at all times. The calculus may appear firmly caught within the loop, as usually happens when the cystoscope has been removed prior to the final pull, or it may fall into the bladder as the loop is withdrawn. In some instances a second attempt is necessary, since the stone may slip out of the loop at a narrow meatus. An indwelling ureteral catheter is used for twenty-four to forty-eight hours after operation.

The success of the procedure depends primarily on introducing the modified catheter beyond

the level of the stone. However, the loop provides an excellent means of dilating the ureter below the level of an impassable obstruction due to a stone and when it was so employed in 2 cases the stone subsequently came away spontaneously.

This technic has been employed successfully in 13 consecutive cases. In 3 of these a second attempt was necessary, since the calculus slipped out of the loop at the level of the ureteral orifice. The calculi in all of these cases occupied the pelvic segment of the ureter, the highest one having been arrested 9 cm. above the ureteral meatus.

*Obstruction.*—Deming<sup>26</sup> states that ureteropelvic obstruction due to extrinsic and intrinsic lesions of the ureter is a clinical entity and can be discussed as such by deleting all unknown and doubtful factors.

Causes of intrinsic obstruction at the ureteropelvic junction are thickening of the musculature, development of hyperplastic fibrous tissue and fibrous contracture which produces a small stoma. Causes of extrinsic obstruction are strands of fibrous tissue running across the ureter at the junction and aberrant vessels. Deming has selected for study only those cases in which the sole cause for obstruction was one of these and has deleted all those cases in which the obstruction may have been influenced by any other factor.

Deming's group numbers 82 cases, in each of which operation was performed. Thirty-five patients were male, and 47 were female. Thirty-seven had involvement of the right kidney and 29 of the left kidney. Sixteen had bilateral lesions. The greatest incidence of bilateral involvement is found in the second decade of life, but the largest percentage of infections is evident in the later decades. Thirty-five of the kidneys were infected. During the first two decades of life male patients were twice as frequent as female patients. After the twentieth year, female patients predominated. During the first two decades of life, the left kidney was more frequently involved than the right kidney. This is in accord with the general opinion that congenital abnormalities of the urinary tract are more common on the left than on the right side.

During the first two decades of life, the extrinsic and intrinsic lesions were distributed about equally. In the third decade, in 9 cases there was definite thickening of the junction and in 1 there was contraction. Aberrant vessels

25. Balkus, V. A.: A Looped Catheter in the Treatment of Ureteral Calculi, *J. Urol.* 50:667-672 (Dec.) 1943.

26. Deming, C. L.: Ureteropelvic Obstruction Due to Extrinsic and Intrinsic Lesions of the Ureter as a Clinical Entity and Its Treatment, *J. Urol.* 50:420-431 (Oct.) 1943.

were common, and it was not at all clear in some cases in which there were both bands of fibrous tissue and vessels whether the vessels or the adhesive bands of fibrous tissue were the primary factor. In the fourth and fifth decades of life distribution of extrinsic and intrinsic lesions was about equal. In the seventh decade there were only 2 cases, in both of which the lesion was intrinsic. The total number of intrinsic lesions was 37, while the total number of extrinsic lesions was 50, 24 of which were due to bands of fibrous tissue and 26 to vessels. There is no doubt that there is a congenital factor which plays a large part in the early decades of life. Aberrant vessels are, of course, congenital.

The object of plastic procedures should be maintained: (1) to produce a physiologic emptying of the renal pelvis by one plastic operation or a combination of plastic operations and (2) to preserve the renal function by maneuvering the kidney into a position favorable for preservation of the physiologic function of the pelvis and by conserving all aberrant vessels. The surgical procedures can be classified roughly as (1) nephrectomy, (2) plastic procedures on the renal pelvis, (3) plastic procedures on the ureter, (4) combined plastic procedures on the pelvis and the ureter and (5) nephropexy. Some patients were treated with a combination of these operations.

Nephrectomy was done only when it seemed essential, as in cases in which the cortical substance of the kidney had been destroyed completely. In this series nephrectomy was done in 40 cases (about 48 per cent). In every case the kidney belonged to the completely nonfunctioning group. Nephrectomy was common in the first decade and in the later decades of life; it was least common in the adolescent period. Nephrectomy was done in only 3 of the 16 cases in which the lesions were bilateral. The remainder of the 40 cases in which nephrectomy was done were those in which there had been a relatively long duration of symptoms, which caused complete destruction of the cortical portion of the kidney.

Twenty-seven patients were treated by various plastic procedures on the pelvis and on the ureters, 10 by ureteropyeloplasty, 7 by reimplantation of the ureter, 3 by the Rammstedt operation and 2 by Y-plasty. Resection of the redundant pelvis, which was done in 13 cases, was distributed more or less throughout the decades of life but was used only once on a patient in the first decade of life.

In 15 of the 42 kidneys conserved, the ureteropelvic obstruction was corrected by lysis of the

kidney and the upper part of the ureter by nephropexy. Nephropexy was most commonly used for patients in the second decade of life. In many cases nephropexy was done in conjunction with plastic procedures.

In the 15 cases in which treatment was by plastic procedure and nephropexy alone, all the patients were relieved successfully of their symptoms and renal function was preserved. Ten of the 27 patients on whom the various plastic measures were used had supplementary nephropexy. In 2 of the cases of plastic procedure the result must be considered unsuccessful because subsequent nephrectomy was required. Both of the patients had ureteropyeloplasty of the Finney type.

Two of the patients treated by the Rammstedt operation leaked urine for one and two weeks respectively, but the urine did not become infected, and the patients were entirely relieved of their symptoms. The postoperative retrograde cystoscopic studies in these cases show that the pelvis empty and that the physiologic function of the kidneys is maintained. Patients who have reimplantation of the ureter into the dependent portion of the pelvis did well. For suture material no. 00000 chromic catgut was used for individual sutures, reinforced with a layer of fascia. Urinary antiseptics were used in all cases both therapeutically and prophylactically. Since the advent of sulfonamide compounds, drainage has not been used in the plastic procedures except in those cases in which infection existed at the time of operation.

The results of Deming's experience with patients suffering from obstruction of the ureter at the pelvic junction are as follows: There have been no operative deaths. Nearly all types of plastic procedures have been tried, and there have been only 2 cases in which plastic procedures were unsuccessful. All other patients were entirely relieved of their symptoms, and the kidneys functioned well. Nephrectomy was done in 3 cases of bilateral ureteropelvic obstruction in which hydronephrosis was complete, without any function in the kidney which was removed. In a relatively large number of cases nephrectomy was done when there was unilateral nonfunctioning hydronephrosis, which indicated in most cases long periods of obstruction.

Kidneys which are infected require drainage when plastic operations are done. For the last few years the gallbladder T tube has given satisfactory results. A no. 12 to no. 14 F. tube is inserted into the normal ureter through a small longitudinal incision about 4 cm. below the field of plastic repair, with the lower arm extending downward 1 cm. and the longer arm extending

upward well into the pelvis of the kidney. Two or three extra holes are cut into this arm to provide adequate drainage. By this method the surgeon can avoid a nephrostomy incision. The method also offers an opportunity to irrigate the pelvis and, by closing the tube, to induce normal flow of urine down the ureter. This tube is left in place ten to fourteen days and then can be removed readily. By the end of this time a sufficient walled-off fistulous tract is produced so that one would not anticipate any difficulty of healing of these wounds. No untoward accidents have happened, nor have there been any draining ureteral fistulas. Some ureters leak a little urine for a day or so, but the majority do not drain any urine.

From experience with these cases of extrinsic and intrinsic ureteropelvic obstruction, Deming concludes: Fundamental surgical principles for plastic procedures in general can be applied in the correction of obstruction of the ureteropelvic junction. No one plastic procedure is adequate for the correction of all types of ureteropelvic obstruction. Lysis with nephropexy is adequate in many cases. The Rammstedt technic should be applied more frequently than it is and should be accompanied by fixation of the kidney. Conservation of the aberrant blood vessels is essential. All infected kidneys must have drainage after plastic procedures. Infection of the kidney clears more rapidly after ureteral reimplantation than after ureteropyeloplasty. Chemotherapy is a great adjunct to plastic surgery of the renal pelvis. However, the surgeon should not sacrifice good technic because of the use of the sulfonamide compounds. Since diagnosis of ureteropelvic obstruction is possible when the patient is an infant or a child and the various plastic procedures can be used successfully, the number of cases in which nephrectomy is performed should be reduced. Uninfected hydronephrotic kidneys that have impaired function due to ureteropelvic obstruction should not be harmed at the time of plastic procedures by infection produced with the use of drainage tubes and splints.

*Ureterocele.*—Emmett and Logan<sup>27</sup> report data on a case of ureterocele with prolapse through the urethra. The patient was a girl aged 2 years who since infancy had had urinary frequency, incontinence and dysuria. The urine contained pus, and the excretory urogram revealed some dilatation of the right ureter and kidney and a

large filling defect in the bladder. At cystoscopy a large mass was encountered lying in the base of the bladder. The mass could be moved from side to side and was attached to the right side of the base of the bladder. Several cuts were made in this tumor mass with the Bugbee electrode, but there was no distinct collapse of the mass, such as is usually seen in the ordinary case of ureterocele. By means of the no. 18 F. Thompson infant resectoscope the mass was removed completely. Afterward the child voided normally, and all her urinary symptoms disappeared.

In a review of the literature, it was found that data on more than 37 similar cases had been reported. In 37 cases reported the patients were female. Twelve were children who ranged in age from 13 days to 14 years. Only 5 of the 12 children survived operation. The first patient reported in the literature who had a prolapsed ureterocele and who survived an operation was a girl 14 years of age. Two of the older patients, who were between 20 and 30 years of age, had had prolapses of their ureteroceles when they were younger, 1 when she was only 8 years of age.

The cause and the pathogenesis of ureterocele have been discussed widely. The consensus seems to favor a congenital origin. As a result of congenital stenosis of the ureter, which also may be due sometimes to an inflammatory condition, and probable congenital weakness of the wall of the lower part of the ureter, dilation of this part of the ureter takes place and then ballooning out into the bladder occurs. Prolapse occurs when the lesion becomes large. The size and the appearance of the prolapsed ureterocele have been compared to those of a ripe fig or a tomato. Ureteroceles are lined on their vesical aspect by vesical mucosa and internally by ureteral mucosa, between which are fibrous tissue and some smooth muscle fibers.

Prolapse of the ureterocele through the urethra is accompanied by pain, dysuria and bleeding. Anuria occurs if the tumor blocks the urethral opening completely. Frequently the diagnosis can be made on seeing the lesion, providing that the physician is aware of the possibility of occurrence of the condition. The diagnosis can be confirmed by excretory urography and cystoscopic examination.

In most of the cases reported in recent years in which an accurate preoperative diagnosis has been made, open surgical methods of treatment have been employed. The most common procedure is to open the bladder suprapubically and excise the protruding ureterocele. Most uretero-

27. Emmett, J. L., and Logan, G. B.: Ureterocele with Prolapse Through the Urethra, *J. Urol.* **51**:19-23 (Jan.) 1944.

celes can now be cared for transurethrally. In the average case simple excision of the ureteroceles with the cutting diathermy current will prove sufficient, as the collapsed sac left behind will atrophy or slough away. In the occasional case, however, as in the one reported by Emmett and

Logan, the walls of the sac may become so thickened from inflammation, trauma and edema that it is of sufficient bulk to act as a foreign body of more or less solid consistency. In such a case complete removal of the sac with the resectoscope will be necessary.

## TREATMENT OF RHINORRHEA AND OTORRHEA

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BALTIMORE

In rhinorrhea and otorrhea the cerebrospinal fluid is discharged from the nose and the ear respectively. Both conditions are due to a fistula connecting the cerebrospinal spaces—either the subarachnoid spaces or the ventricular system—with the exterior. Pneumocephalus (air in the cranial chamber) is frequently but not necessarily in association. If the fistula is large enough, air enters the cranial chamber as the fluid passes out. When there is a ball valve arrangement in the fistulous tract, coughing and sneezing may force large quantities of air into the cranial chamber, and if the frontal lobes are pierced a steadily enlarging air-filled cavity in a frontal lobe gradually erodes its way into a lateral ventricle, and the entire ventricular system together with the subarachnoid spaces is then filled with air; this is the terminal stage. The surgical attack on rhinorrhea and otorrhea, however, is precisely the same, for both are due to the same underlying cause, a fistula; closure of this cures both.

The two great causes of rhinorrhea and otorrhea are (1) fractures of the skull and (2) openings created by operative procedures. Less frequent causes are (3) erosions by tumors or infections and (4) congenital abnormalities. Fortunately many fistulas heal spontaneously. Spontaneous healing occurs particularly in otorrhea following fractures of the petrous portion of the temporal bone and is due to the relatively long course of the channel through the petrous bone and the relatively greater thickness of the soft tissues. Post-traumatic otorrhea will usually stop in less than two weeks, and frequently in a day or two. There is therefore no indication for operative intervention for otorrhea of such short duration; this is fortunate, because it would be difficult to determine the site of the fistula, i. e. whether it was in the middle or the posterior cranial fossa.

Post-traumatic or postoperative fistulas into the frontal or ethmoid sinuses or fistulas created by operations on the mastoid are frequently slow to heal and may never heal, or they may close and periodically reopen. The explanation is that

the drainage tract is usually larger and the soft tissues relatively thin, being only mucosal lining. Usually the fistula persists too long to await nature's efforts at closure by granulation tissue.

A cerebrospinal fistula is always a potential source of meningitis or cerebral abscess, and if the draining fluid persists long enough several attacks of meningitis may occur, and eventually one will be fatal. Many years may indeed elapse before death, or it may come quickly—depending on the chance of infection within the paranasal or mastoid sinuses. Sulfonamide drugs and penicillin are helpful and may prolong life, but the danger of a fatal termination is always present nevertheless. The high percentage of recoveries from meningitis in the presence of cerebrospinal fistulas is due to the continuous drainage afforded by the opening.

It is my strong feeling that a fistula (except those following injury to the petrous bone) should never be left open longer than two weeks unless the fluid is unmistakably diminishing. Closure is now a comparatively simple, danger-free procedure and leaves nothing to chance. The only exception to this statement is closure in the presence of a known, well developed intracranial infection. In 1 of my cases (case 2) organisms were isolated from the fluid but there was no purulent meningitis. In case 8 a cerebral abscess became full blown three weeks after the fistula was closed, but it was certainly there before the operation; at least nothing was lost in the attempt, and had it been closed earlier the abscess would never have developed.

Plum<sup>1</sup> (1931) reported a fistula of eighteen years' duration; Fribourg-Blanc, Lassalle and Germain<sup>2</sup> (1934), one of seventeen years' duration, with intermittent closure for short periods. Wurster<sup>3</sup> (1937) reported one of six and a half

1. Plum, F. A.: Cerebrospinal Rhinorrhea, Arch. Otolaryng. 13:84 (Jan.) 1931.

2. Fribourg-Blanc, Lassalle and Germain: Deux observations de pneumocèle intracrânienne, Rev. neurol. 2:51, 1934.

(Footnotes continued on next page)

years' duration; it finally healed spontaneously and had remained closed three years at the time of his report. Thomson reported on this condition<sup>4</sup> (1899) in a patient, which had persisted several years. A number of spontaneous cures are recorded in the literature, but there are many more fatalities.

#### LOCALIZATION OF THE BONY AND DURAL OPENINGS

When rhinorrhea follows operative procedures, the site of the fistula is along the path of the operative attack and is therefore usually not difficult to find. If the fistula follows a depressed fracture of the skull the depression may indicate its position. But if there is no depression roentgenograms of the frontal region (frontal, ethmoid and sphenoid sinuses) are all important. Even then its location may be in doubt. Drainage of fluid from one nostril predominantly is fair evidence that the fistula is on the corresponding side of the anterior fossa, but that is by no means dependable proof. Cairns<sup>5</sup> (1937) found an opening on the contralateral side; it was explained by a blood clot which filled the other nostril. Then, too, one of the frontal sinuses may be closed for other reasons. There are times when only an exploratory operation will determine the site of the opening. Moreover, there may be bilateral fistulas (Cairns,<sup>5</sup> Adson,<sup>6</sup> Eden,<sup>7</sup> Campbell, Howard and Weary<sup>8</sup>).

To differentiate between a fistula of the frontal and one of the ethmoid sinus may at times be difficult. It is my impression that the differential diagnosis can often be made by observing the cerebrospinal outflow, i. e., if when the head is tilted forward there is a sudden increase in the volume of fluid, it is apparent that the fluid has been contained in a reservoir and is pouring over the edge and that the fistula is located in a frontal sinus. And if the flow of fluid is not altered

by tilting the head, an opening in the ethmoid or in the sphenoid cells is indicated.

In 1 case (case 10) I was not able to find an opening in the bone through which fluid poured into the middle ear and thence down the eustachian tube and the pharynx and when the patient was lying down from the nose. The opening into the middle ear was found, but its closure was unsuccessful.

If there is any difference of opinion concerning the advisability of operation for cerebrospinal fistulas, it can be only in those few cases in which the site or side of the fistula cannot be determined beforehand, but even in such unusual cases bilateral exposure is preferable to the almost certain fatality that lies ahead.

#### METHODS OF SURGICAL CLOSURE OF THE FISTULA

The first successful treatment of rhinorrhea was reported by me in 1926.<sup>9</sup> Autogenous grafts of fascia lata were sutured over the dural opening behind a depressed fracture of the orbit and the frontal sinus. Before this Grant<sup>10</sup> (1923) had attempted to close an opening through a cranial exposure but was not successful, and Teachenor<sup>11</sup> (1923) debated whether to uncover a frontal fistula in order to close the dura. Cushing<sup>12</sup> (1927) reported successful treatment in 3 cases in which rhinorrhea followed removal of orbitoethmoid osteomas; in each a piece of fascia lata was laid over the dural defect. Prior to these cures, 2 patients with similar conditions had died of infection; it was these deaths that prompted the closure with fascia. Rand<sup>13</sup> (1930), McKinney<sup>14</sup> (1932), Cairns<sup>5</sup> (1937), Gissane and Rank<sup>15</sup> (1940), Eden<sup>7</sup> (1942) and Campbell, Howard and Weary<sup>8</sup> (1942) have since reported cures by the use of fascial transplants. The fascia may be taken from the thigh

9. Dandy, W. E.: Pneumocephalus, *Arch. Surg.* **12**:949 (May) 1926; Pneumocephalus, in Lewis, D.: *System of Surgery*, Hagerstown, Md., W. F. Prior Company, Inc., 1943, vol. 14, pp. 311-319.

10. Grant, F. C.: Intracranial Aerocele Following a Fracture of the Skull, *Surg., Gynec. & Obst.* **36**:251, 1923.

11. Teachenor, F. R.: Pneumoventricle of the Cerebrum Following Fracture of the Skull, *Ann. Surg.* **78**:561, 1923.

12. Cushing, H.: Experiences with Orbito-Ethmoidal Osteomata Having Intracranial Complications, *Surg., Gynec. & Obst.* **44**:721, 1927.

13. Rand, C. W.: Traumatic Pneumocephalus: Report of Eight Cases, *Arch. Surg.* **20**:935 (June) 1930.

14. McKinney, R.: Traumatic Pneumocephalus, *Ann. Otol., Rhin. & Laryng.* **41**:597, 1932.

15. Gissane, W., and Rank, B. K.: Post-Traumatic Cerebrospinal Rhinorrhoea with Case Report, *Brit. J. Surg.* **27**:717, 1940.

3. Wurster, H. C.: Cerebrospinal Rhinorrhea: Report of an Unusual Case, *J. Indiana M. A.* **30**:199, 1937.

4. Thomson, St. C.: *The Cerebrospinal Fluid: Its Spontaneous Escape from the Nose*, London, Cassell & Co., 1899.

5. Cairns, H.: Injuries of the Frontal and Ethmoidal Sinuses with Special Reference to Cerebrospinal Rhinorrhoea and Aeroceles, *J. Laryng. & Otol.* **52**:589, 1937.

6. Adson, A. W.: Cerebrospinal Rhinorrhea, *Ann. Surg.* **114**:697, 1941.

7. Eden, K. C.: Traumatic Cerebrospinal Rhinorrhoea, *Brit. J. Surg.* **29**:299, 1942.

8. Campbell, E.; Howard, W. P., and Weary, W. B.: Gunshot Wounds of the Brain, *Arch. Surg.* **44**:789 (May) 1942.

or from the covering of the temporal muscle. The fascia may be sutured in place or when this is not practical laid over the defect.

To cure rhinorrhea or otorrhea, it is not necessary that both the opening in the bone and that in the dura be closed. The closure of either will cure the condition. On the whole, closure of the dura is preferable. In 2 of the cases in this series (cases 4 and 5) the bone was waxed (1934 and 1937). This method of closing the defect in the bone was reported by Graham<sup>16</sup> (1937) and later by Adson<sup>6</sup> (1941).

Packing the wound with iodoform gauze was advocated by Peet<sup>17</sup> (1928) and has been used by Gurdjian and Webster<sup>18</sup> (1944). However, packing of the wound is now rarely done, most wounds being closed without drainage.

#### TREATMENT OF FISTULAS FOLLOWING CRANIAL OPERATIONS

As previously noted, when rhinorrhea develops after a cranial operative procedure the site of the fistula is evident or nearly so. In frontal craniotomy an unusually large frontal sinus may be opened. This is such a potential risk that surgeons should always know from roentgenograms the size of the frontal sinus, and when a low frontal approach is required entry into the sinus can be avoided by correspondingly shifting the bony incision. There are times when entry cannot be avoided, as for example in attacking tumors that invade the frontal sinus. When a frontal sinus is opened a flap of dura can be reflected over the opening and tightly sutured to the overlying galea. If the opening is disclosed by rhinorrhea after the operation is completed the wound should be reopened immediately and this procedure carried out (case 3). During cerebellar operations for trigeminal neuralgia, Ménière's disease, tumor of the acoustic nerve and other conditions a mastoid cell is occasionally opened; the dura should be immediately sutured over it to prevent immediate or subsequent infection.

In another case (case 4) rhinorrhea followed a frontal craniotomy in which the frontal sinus was not opened but in which the dura had been

accidentally stripped from the floor of the anterior fossa. Reexploration revealed an opening as large as a slate pencil into an ethmoid cell, and in the opening was an old elevated fracture (of many years' duration). This was plugged with bone wax (1934); there was no corresponding dural opening. The fluid had escaped through the dural suture line, thereby gaining access to the subdural space, where it entered the defect in the bone.

In another case (case 5) an opening in the ethmoid cell was made when the orbital roof was rongeured away in preparation for the removal of an orbital tumor. This opening was waxed later in the day and the dura reflected over it and sutured in place. As a precaution against the possibility of such an accident in operations on orbital tumors, the dura covering the orbital roof is now always reflected mesially; it can then be used to cover any opening in the ethmoid cells.

Nasal operations in which the cribriform plate is punctured and operations in which hypophysial tumors are attacked by the nasal route are other sources of rhinorrhea. Neither of these was encountered in this series.

#### OTORRHEA FOLLOWING OPERATIONS ON THE MASTOID

There are 4 cases in this series in which otorrhea followed operation on the mastoid; in each case it was due to the operator's chiseling through the mastoid bone and the dura. In 3 of the cases the bony defect was in the roof of the petrous bone about 2 cm. inside the lateral wall of the skull; this is probably the most common site. According to the law of probability, therefore, this is the logical place to look for the fistula. The corresponding dural defect can be sutured and if necessary reenforced by a piece of fascia lata or more conveniently by a layer of the sheath of the temporal muscle. The latter serves just as well as fascia lata for this purpose and is immediately available in the operative area. If the dural defect is near the surface the fascia is sutured in place; if it is too deep it can be laid over the suture line and treated with 3.5 per cent solution of iodine to promote adhesions. It was possible to suture in all of these cases. In a fourth case the dural opening was just back of the mastoid bone. This opening was sutured and covered by fascia, which was merely laid over the suture line and treated with iodine solution; the dura was too thin to support additional sutures. It is evident that an attempt to find the fistula by reexploring the original

16. Graham, T. O.: *Cerebrospinal Rhinorrhoea*, J. Laryng. & Otol. **52**:344, 1937.

17. Peet, M. M.: *Symptoms, Diagnosis and Treatment of Acute Cranial and Intracranial Injuries*, New York State J. Med. **28**:555, 1928.

18. Gurdjian, E. S., and Webster, J. E.: *Surgical Management of Compound Depressed Fracture of Frontal Sinus, Cerebrospinal Rhinorrhea and Pneumocephalus*, Arch. Otolaryng. **39**:287 (April) 1944.



wound of the mastoid would be unproductive, because nothing could be done to the dural opening unless a large area of bone were removed. The incision, therefore, is made anterior to the old incision, so that the roof of the petrous bone can be exposed and the overlying dural defect reached with adequate room for closure; the attack is entirely extradural.

In case 10 a postoperative fistula was found in an unusual site. After the removal of a tumor of the acoustic nerve (by me) that had deeply eroded the petrous bone, it was discovered that a fistula opened into the middle ear and that the fluid was discharged into the pharynx. The tumor had eroded the posterior wall of the middle ear. Since rhinorrhea was an immediate postoperative sequel, the fluid had to come from this site. The ear drum bulged almost to the point of rupture, and after two unsuccessful attempts to find the fistula it was disclosed by injecting methylthionine chloride (methylene blue) (Dr. John Baylor's idea) through the drum with a tiny needle; the walls of the fistula were then colored by the dye. But an attempt to close it with sutures and a fascial transplant was unsuccessful. It would not have been possible to suture a dural graft over the large defect intracranially, but an attempt was made to wax the bed from which the tumor had been extirpated. Perhaps a more careful plastic operation with fascia would now bring results. This is the only case in the series in which there was failure to close a fistula. The patient subsequently died of meningitis; the rhinorrhea persisted one year after removal of the tumor.

#### RHINORRHEA AND PNEUMOCEPHALUS FOLLOWING DEPRESSED FRACTURES OF THE FRONTAL SINUS

A depressed fracture of the frontal sinus is frequently visible or palpable. In 2 of the cases in this series (cases 1 and 2) it was necessary only to elevate the depressed fragment and remove it temporarily to close the opening in the dura with a fascial transplant. If there is not an adequate exposed area of dura, an additional amount of the inner table of the frontal sinus must be rongeured away until the desired exposure is obtained. The elevated or removed fragment of bone can then be replaced in its proper position and will usually hold without wiring. Without the existence of a depressed fracture a lateral cranial exposure would be preferable to removing the walls of the frontal sinus.

In these cases (1 and 2) both patients had pneumocephalus, with a large frontal defect and

ventricular filling. Both were unconscious at the time of admission to the hospital and both recovered. There were no other cases of pneumocephalus in the series.

#### RHINORRHEA FOLLOWING NONDEPRESSED FRACTURES OF THE FRONTAL AND ETHMOID SINUSES

Fractures of the frontal sinus need not of course be depressed. A linear fracture will tear the underlying dura and cause rhinorrhea. With such a lesion roentgenograms are essential to determine whether the tear is on the right, the left or at times both sides and to differentiate between a crack in the frontal and the ethmoid sinus. To locate the fracture and to disclose intracranial air are important functions of roentgenography in this field.

For revealing a fistula resulting from a non-depressed fracture an intracranial exposure is almost essential and provides a much better cosmetic result. To rongeur away both walls of a frontal sinus in order to expose and close a fistula beneath, as advocated by Teachenor<sup>19</sup> (1923 and 1927), would produce an unsightly deformity. A cranioplasty leaves no deformity, and the incision is entirely under the hair line. My choice of operative attack is a small bone flap, such as is used for hypophysial tumors, with a concealed incision. Whether or not the dura is opened depends on the amount of room necessary to close and reenforce the opening with fascia. With careful closure of the dura the opening in the bone need not be closed, though covering it with bone wax adds safety if the opening is small. Coleman<sup>20</sup> (1937) has used this method of attack. It was first tried by Grant<sup>10</sup> (1923) in probably the first operative attempt to cure pneumocephalus, but the operation was unsuccessful because of uncontrollable bleeding.

Adson<sup>6</sup> (1941) reported 6 cases in which rhinorrhea was cured and advocated a bilateral frontal approach with a coronal incision. Because of troublesome bleeding he routinely ligated the longitudinal sinus, at times both before and after. He reasoned that: (1) he could be sure of finding the fistula on either side (when the side was unknown) or on both sides (when bilateral); (2) better elevation of the meninges was possible because of added room, and therefore (3) better invagination of the edges of the dural fistula was

19. Teachenor, F. R.: Intracranial Complications of Fracture of Skull Involving Frontal Sinus, *J. A. M. A.* 88:987 (March 26) 1927; footnote 11.

20. Coleman, C. C.: Fracture of the Skull Involving the Paranasal Sinuses and Mastoids, *J. A. M. A.* 109:1613 (Nov. 13) 1937.

possible during suturation. This is an extensive procedure, and ligation of a longitudinal sinus is a serious addition to it. Moreover, such a wide bone flap broken at the anterior border of the skull must lend itself to opening both frontal sinuses—a complication that every effort should be made to avoid. Cairns<sup>5</sup> (1937) made an enlarged unilateral exposure that was carried some distance across the midline, so as to include much of the other frontal lobe. I should much prefer two separate unilateral flaps (two operations) if bilateral fistulas are present (as in case 11) or even if the side of the fistula is not known (this is only occasionally uncertain). It is usually possible to get adequate exposure by an extradural unilateral approach, and if it is not possible opening the dura and evacuating the cisterna chiasmatis will provide more room than is necessary.

#### TREATMENT OF OPENINGS IN THE ETHMOID SINUSES

Openings in the ethmoid cells are somewhat more difficult to expose and require the small anterior bone flap just described; it may or may not be necessary to open the dura. If the dura is stripped from the anterior fossa, the opening in the bone may be waxed and a piece of temporal fascia laid over it. Treatment of the fascia with 3.5 per cent solution of iodine will promote adhesions. At this depth and with a thin, easily tearable dura, suturing is difficult or impossible. German<sup>21</sup> (1944) reported 5 cases in which a flap of dura was turned down from the falx cerebri and the crista galli and thrown across the dural defect. Gurdjian and Webster<sup>18</sup> (1944) reported a case in which this procedure was used. For this procedure the dura must of course be widely opened, as in any cranioplastic procedure.

#### REPORT OF CASES

##### CASE 1.—*Post-traumatic fistula with a ball valve arrangement into the right frontal sinus.*

T. S., a white man aged 70, was seen on Feb. 20, 1925. There had been an intermittent discharge of watery fluid from the nose since an automobile accident forty-five days before. He was semicomatose on admission to the hospital. His pulse rate was 50 and his temperature was 99.8 F. The white cell count was 8,000. Operation for presumed subdural hematoma was done forty-five days after his injury; pneumocephalus was encountered; air spurted and the brain collapsed when the thin cortex was incised. An opening in the dura and the frontal sinus was disclosed when the frontal lobe was retracted. After the wound was closed the depressed fracture was elevated and the dural defect

repaired with a transplant of fascia lata, which was sutured. Entrance of air into the cranial chamber had been by a ball valve arrangement of the fistulous tract; the dural opening was not superimposed on the break in the bone. Air, therefore, could be blown into the brain by coughing and sneezing, but the increased intracranial pressure forced the dura against an intact bony surface and prevented escape of the air. Roentgenograms taken before the cranial operation showed large ventricles and a large frontal defect completely filled with air, but because of his condition I had not waited to inspect them.

*Subsequent Course.*—Recovery was uneventful; the pneumocephalus immediately cleared.

This case was presented in an earlier publication and was the first in which a fistula causing rhinorrhea and pneumocephalus was cured by fascial repair of the opening (fig. 1).

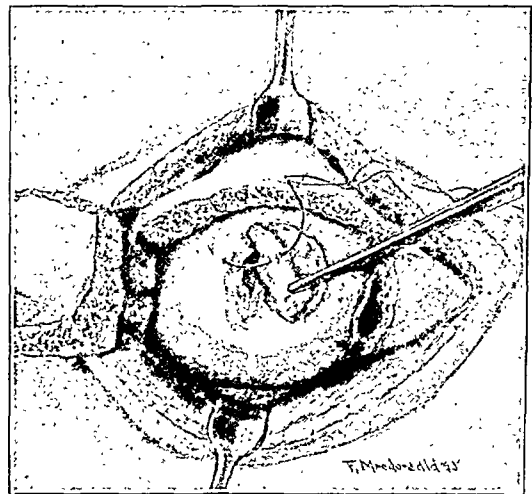


Fig. 1 (case 1).—Drawing showing a facial transplant sutured over the dural defect beneath a depressed fracture in the supraorbital region. It will be noted that the dural opening is not in line with the opening in the frontal sinus. This is a ball valve channel. The air is blown through the dural opening, and the intracranial pressure then forces the dura against the bone and prevents its exit. The air destroyed the right frontal lobe and then burst into the ventricular system, producing total pneumocephalus.

##### CASE 2.—*Post-traumatic fistula into the left frontal sinus with pneumocephalus and ventricular filling (fig. 2A).*

W. F., a white man aged 20, was seen on Nov. 23, 1928. The patient was comatose when admitted to the hospital. There was a constant drip of clear fluid from the nose. Two months previously he had been in an automobile accident, after which he was unconscious for two days and then irrational for several days. When he got out of bed rhinorrhea was observed from the left nostril and had since persisted.

On admission to the hospital his temperature was 105 F.; the spinal fluid was xanthochromic and contained 20,700 cells; the white cell count was 17,000. Streptococci were grown from the spinal fluid, but the fluid was not purulent. When his head was tipped forward a half-cup of fluid rolled out.

21. German, W. J.: Cerebrospinal Rhinorrhoea—Surgical Repair, *J. Neurosurg.* 1:60, 1944.

Roentgenograms showed the lateral ventricles filled with air and a large air-filled defect of the left frontal lobe. A depressed fracture of the left frontal bone and a crack in the right frontal sinus were disclosed. There was complete paralysis of the left oculomotor nerve.

Operation was performed on Nov. 24, 1928. The old depressed fracture of the left frontal bone was elevated. The incision was made along the supraorbital ridge. An opening 2 cm. long and 1 cm. wide was disclosed beneath it; air escaped. A piece of fascia lata was sutured over the opening and the fragment of bone replaced.

*Subsequent Course.*—Recovery was uneventful and the rhinorrhea did not recur (fig. 2 B). Meningitis did not develop. The patient is now serving with the marines in the South Pacific.

*CASE 3.—Postoperative defect in a frontal sinus.*

T. I., a white man aged 58, was seen on Jan. 26, 1940. Immediately after removal of an enormous osteosarcoma of the skull, rhinorrhea appeared (fig. 3). At

The fluid had now escaped through the dural suture lines into the extradural space and through this opening into the pharynx.

*Subsequent Course.*—There was no discharge of fluid after operation. Seven years later (April 19, 1941) the patient died of recurrence of the tumor; there was never recurrence of the rhinorrhea.

*CASE 5.—Postoperative defect in the ethmoid cells following removal of an orbital tumor by the transcranial route.*

R. H., a white woman aged 35, was seen on April 7, 1937. Immediately after removal of an intracranial and intraorbital dural meningioma, rhinorrhea appeared (fig. 5). It was clear that an ethmoid cell had been opened. On the following day the wound was reopened, and the open cell was found and covered with bone wax. A flap of orbital fascia was placed over the waxed opening and treated with 3.5 per cent solution of iodine to promote adhesions. Recovery was uneventful. There was no subsequent leak of cerebrospinal fluid.

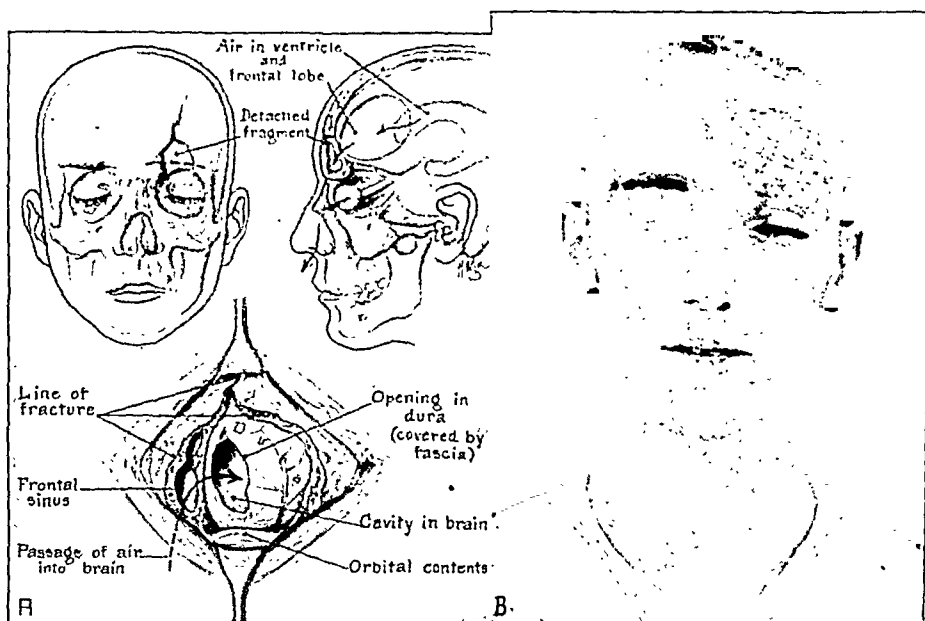


Fig. 2 (case 2).—A, drawings illustrating essentially the same condition as in case 1, i. e., advanced pneumatic cephalus with destruction of the frontal lobe and filling of the ventricular system. In this case the dural opening which was covered with fascia, as in case 1, was also of a ball valve type, since the two openings were not superimposed. B, patient two weeks after operation. He was unconscious on admission to the hospital. At the present time, sixteen years after the operation, he is fighting with the United States Marines in the South Pacific.

the time of operation the opening in the frontal sinus was not observed. On the following day the wound was reopened, and a pedicled flap of dura was reflected over the opening and snugly sutured to the galea. The rhinorrhea immediately ceased; recovery was uneventful.

*CASE 4.—Post-traumatic and postoperative opening into ethmoid cells.*

E. L., a white woman aged 26, was seen on Aug. 25, 1934. A glioma was removed with a section of the left frontal lobe. During the operation an assistant jerked the dura, stripping it from the anterior fossa. Rhinorrhea immediately followed the operation.

On the following day the wound was reopened, and an old elevated fracture lying in an opening in the cribriform plate was disclosed (fig. 4). The upturned fragment of bone left an opening as large as a slate pencil into an ethmoid cell. It was covered with wax. The dura was intact; therefore the patient had not had rhinorrhea at the time of the original cranial fracture.

*CASE 6.—Postoperative defect in the left petrous bone and the dura.*

E. W., a white woman aged 27, was seen on July 3, 1934. A cerebrospinal fistula from the left ear had persisted for four years after mastoidectomy. Meningitis was said to have been present at the time of the operation on the mastoid.

At operation a circular opening (about 0.5 cm. in diameter) was exposed in the roof of the petrous bone and about 2 cm. inside the skull (fig. 6). There was a defect in the overlying dura, and cerebrospinal fluid was escaping. Fascia from the temporal muscle was sutured over the dural defect. Then the bony defect was covered with wax.

*Subsequent Course.*—The patient recovered, with no subsequent drainage of spinal fluid.

*CASE 7.—Postoperative defect in the petrous bone and the dura.*

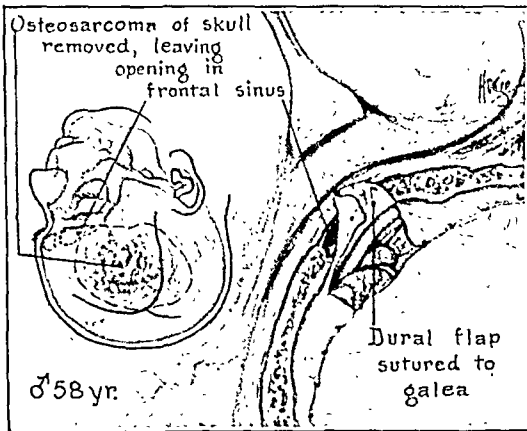


Fig. 3 (case 3).—Operative procedure for removal of an osteosarcoma of the skull: A large dural flap was turned down and the frontal sinus was opened and covered by a flap of dura, which was snugly sutured to the galea.

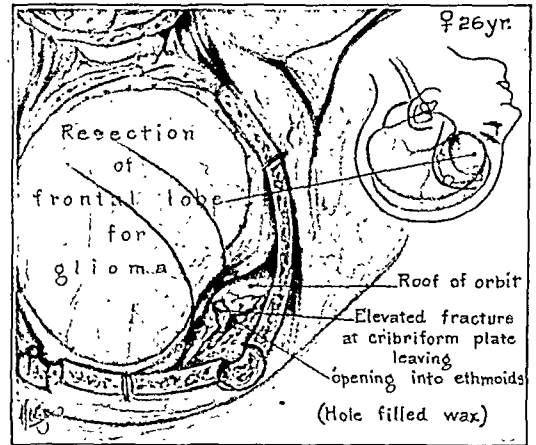


Fig. 4 (case 4).—An old elevated fracture of the cribriform plate, which had lain dormant for many years, was uncovered when the dura was stripped from it at operation for the removal of a tumor of the frontal lobe. The fluid leaked from the dural incision and passed through the old bony defect into the ethmoid cells; the opening was waxed.

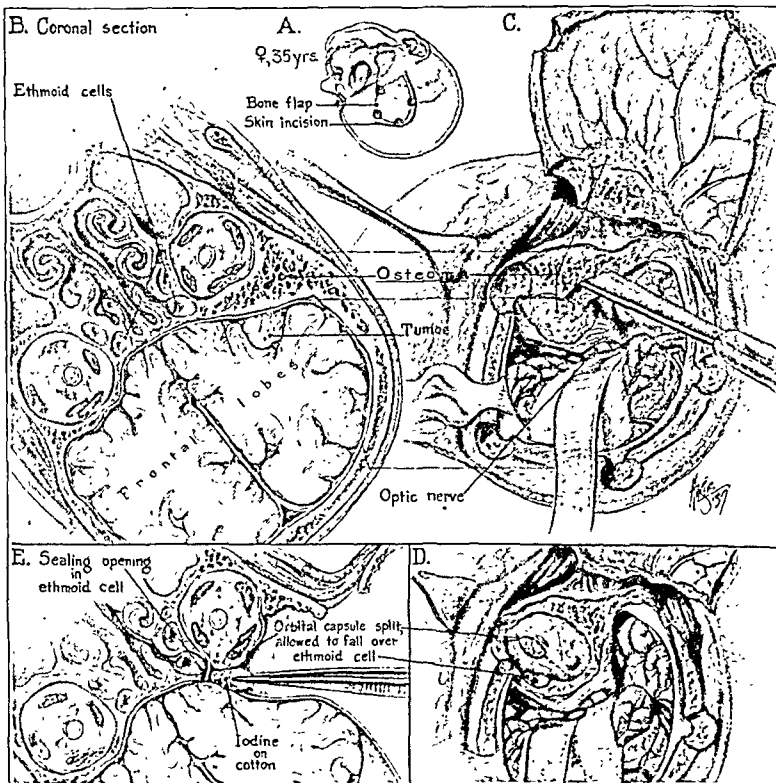


Fig. 5 (case 5).—When the hypertrophied bone caused by an overlying dural meningioma of the orbital roof was being chiseled away, an ethmoid cell was opened, and rhinorrhea followed. The wound was reopened, and a flap of the orbital capsule was thrown over the fistula and treated with 3.5 per cent solution of iodine to stimulate adhesions. In operations of this type the dural lining of the orbital roof is now stripped mesially, so that it can be used if a cell should be opened.

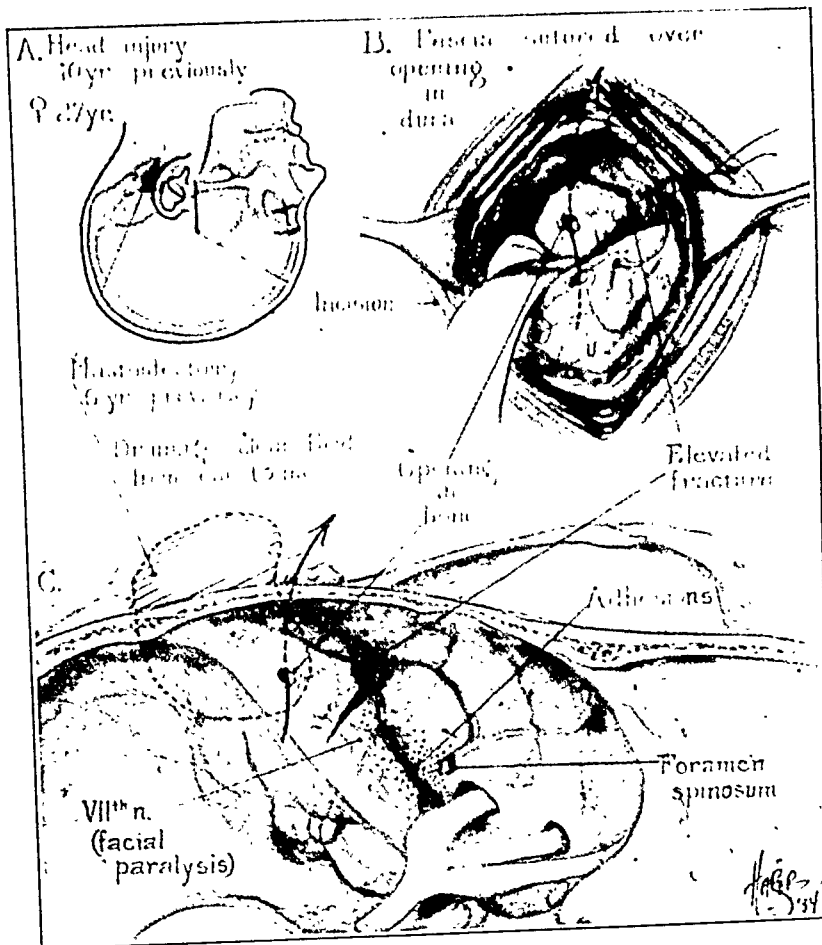


Fig. 6 (case 6).—Drawing showing the postoperative defect created in the roof of the petrous bone and dura by a faulty operation on a mastoid. The dura was closed by suturing a piece of fascia from the temporal muscle, and the opening in the bone was waxed. During the exposure an old fracture of the petrous apex was disclosed, but it had nothing to do with the otorrhea.

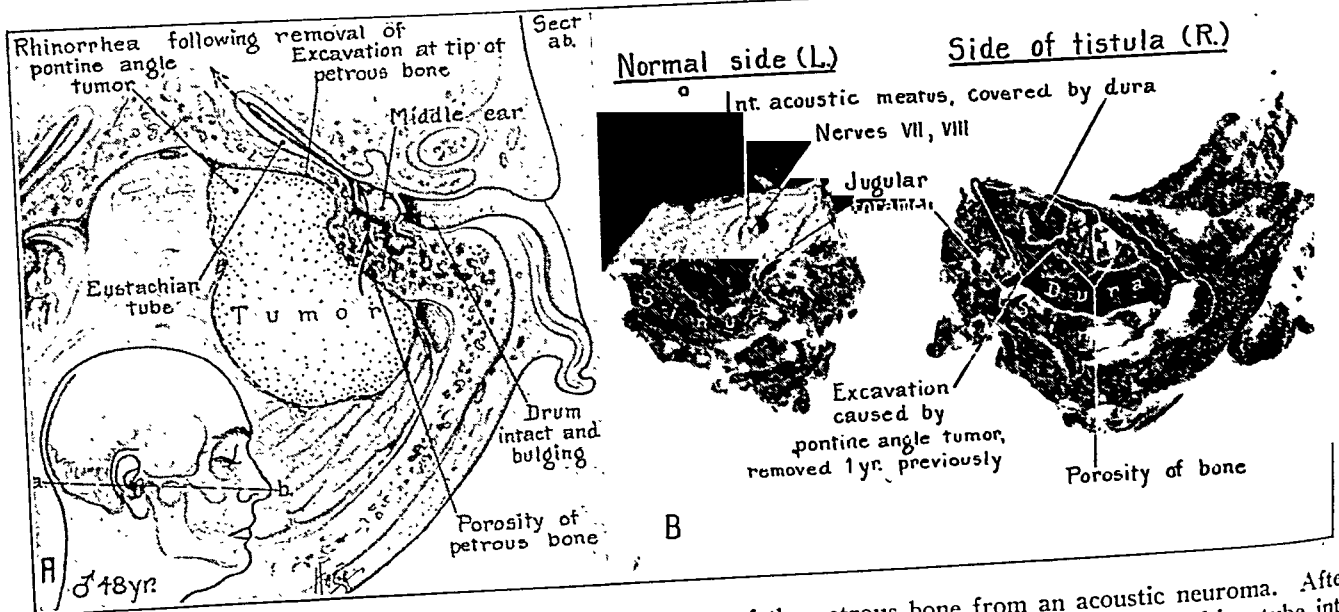


Fig. 7 (case 10).—A, operative sketch showing erosion of the petrous bone from an acoustic neuroma. After removal of this tumor the fistula developed into the middle ear, and fluid passed down the eustachian tube into the pharynx. B, postmortem photographs of both petrous bones, i. e. on the affected and the unaffected side. No defect was found in the petrous bone, but it was extremely porous. An attempt to close the fistula in the cartilaginous lining of the middle ear was unsuccessful. Some time later the patient died of meningitis—his third attack since the onset of rhinorrhea. How the fistula developed in the middle ear is not clear.

M. R., a white woman aged 26, was seen on Aug. 27, 1938. Otorrhea of five years' duration followed immediately after an operation on the mastoid. There was recovery from one attack of meningitis during this period.

At operation an opening (about 1 by 1 cm.) was located in the dura and in the roof of the petrous bone about 2 cm. from the lateral surface of the skull. The temporal lobe protruded through the dural opening and filled the bony defect. This fungus was cut away, the dural defect was closed with silk and a piece of fascia from the temporal muscle was sutured over the closed dura.

*Subsequent Course.*—The patient recovered, with no subsequent otorrhea.

*CASE 8.—Postoperative defect in the petrous bone and the dura.*

F. S., a white boy aged 10 years, was seen on Aug. 21, 1941. A periodic discharge of cerebrospinal fluid from the left ear was noticed after an operation on the mastoid four years before his admission to the hospital. The longest period in which the opening was closed was nine months; the patient never had meningitis.

An operation was performed on Aug. 21, 1941. Over the roof of the petrous bone, 1 cm. from the lateral surface of the skull, there was an opening as large as a lead pencil and a corresponding opening in the dura. Granulation tissue and a cerebral fungus filled the openings. The dural opening was closed with silk, treated with 3.5 per cent solution of iodine and covered with fascia from the temporal muscle. The opening in the bone was not waxed.

*Subsequent Course.*—No discharge of fluid was present at any time after operation.

*CASE 9.—Postoperative defect in the temporal bone and the dura posterior to the right mastoid.*

S. M., a white girl aged 11 years, was seen on Jan. 7, 1944. Since an operation on a mastoid six months previous to her admission to the hospital, there had been intermittent discharge of cerebrospinal fluid from the right ear—about a quarter of a pint (118 cc.) daily. A protruding fungus filled the external auditory meatus. She had survived with complete recovery one attack of meningitis and at the time of hospitalization had a maximum temperature of 100 F. daily; the pulse rate was from 120 to 140.

At operation an opening in the temporal bone back of the petrous portion and a defect in the dura about 1 cm. square were closed with sutures and not reenforced by fascia. The fungus was removed from the external ear.

*Subsequent Course.*—The wound in the external ear became infected. Cerebrospinal fluid did not leak at any time after the operation, but the fever and tachycardia persisted and gradually increased. On the nineteenth day her temperature rose to 105 F. and her pulse rate increased to 170; hemiplegia and coma followed, with death twenty-six days after operation. Multiple abscesses studded the right hemisphere; Staph. aureus was isolated. Sulfadiazine had been given by mouth since her entry into the hospital.

*CASE 10.—Rhinoirrhoea (otorrhea?) through a postoperative defect in the mastoid following removal of a tumor of the acoustic nerve; a fistula into the middle ear.*

L. T., a white man aged 48, was seen on March 4, 1937. After removal of a large tumor of the acoustic

nerve (April 27, 1937) from which there was extensive destruction of the petrous bone, rhinoirrhoea appeared and persisted (fig. 7A and B). I was puzzled that rhinoirrhoea and not otorrhea developed and assumed that the fluid had in some way entered the eustachian tube mesial to the ear drum and then entered the pharynx.

After two attacks of meningitis—(1) pneumococcus type XXIX (Dec. 20, 1937) and (2) Staph. aureus (March 2, 1938)—both of which cleared promptly and miraculously with sulfanilamide, which was just then beginning to be used, the cerebellar wound was opened and the hollow in the petrous bone painstakingly waxed (March 4, 1938), but without any effect on the drainage of cerebrospinal fluid.

Dr. Baylor then found the drum bulging with fluid and injected methylthionine chloride (methylene blue) into it. A blue-stained fistula was located in the posterior wall of the middle ear. This cartilaginous opening was sutured and the adjacent mastoid waxed. The wound broke down with infection, and the sutures were extruded.

The rhinoirrhoea persisted. Several weeks later, on April 6, 1938, he had another attack of meningitis (Staph. aureus) and died.

*CASE 11.—Spontaneous rhinoirrhoea.*

G. S., a white man aged 39, was seen on Sept. 15, 1943. The patient was referred by Dr. E. H. MacKinlay, of McConnellsburgh, Pa.

His complaint was "water flowing from the nose." He had had severe bilateral sinusitis ten years before I saw him; he reported drainage of pus for one year and headaches during the entire time. He has had no trouble with sinuses since then. He had had two unconscious spells: The first, a year before admission to the hospital, lasted two to three hours; the second, one week before, lasted thirty-six hours. The present illness began four months preceding hospitalization, when clear, colorless fluid began to drain from the right side of the nose. There had been no antecedent injury or infection. This drainage had been almost constant for four months. When he was standing or sitting the fluid went down the back of his throat. When he bent forward it poured out of the right nostril in a steady stream. Physical and neurologic examinations gave normal results except for the draining fluid. When he was bending forward about 2 cc. of clear colorless fluid was collected in two minutes. This came exclusively from the right nostril; however, if he turned to the left, the fluid came from the left nostril. For several years he has had occasional generalized convulsions. The blood pressure was 130 systolic and 80 diastolic; a Wassermann test of the blood gave negative results. Roentgenograms of the skull were normal, and a re-examination after the lesion was disclosed at operation did not reveal the small openings in the bone.

A diagnosis of spontaneous rhinoirrhoea through a frontal sinus of undetermined origin, probably from the right sinus, was made. An exploratory operation on the small right frontal lobe was performed on Sept. 20, 1943. A slender strand of tissue slightly larger than the lead in a pencil and 1 cm. long was passed from the tip of the frontal lobe (fig. 8) through an opening in the dura and skull—presumably the outer part of the frontal sinus—but when a probe was passed into the opening a little orbital fat protruded and was excised. It is doubtful, therefore, that this opening passed into the frontal sinus. The strand of tissue bridging the subdural space was excised for microscopic study; the

tissue was of nondescript fibrous character, condensed into two circular strands; no definite nerve tissue could be identified. The dura was stripped from the anterior fossa, the bony opening plugged with wax and a piece of temporal fascia placed over the opening of the dura on its outer surface. A 3.5 per cent solution of iodine was applied to stimulate adhesions.

*Subsequent Course.*—The rhinorrhea continued after operation, but the patient stated that the quantity was about half as much as before. Two months later there had been no change. The frontal region was reexplored Nov. 30, 1943, but the opening was sealed over perfectly. It was then supposed that another fistula was probably on the left side. The left frontal lobe was explored on Dec. 11, 1943, and a similar strand of tissue was found at exactly the same spot as on the right. It was shorter and broader than that in the right—perhaps 0.5 cm. long and as large as a slate pencil. The arachnoid could be seen passing from the frontal lobe around the strand of tissue and was filled with cerebrospinal fluid. There was a defect in the dura and a bony opening—possibly into the outer part of the frontal sinus. The bridge of tissue was cut through, but it was too short to excise for microscopic study. The cisterna at the chiasm was opened to provide room for the operative attack on the fistula. The dura was not stripped from the floor of the skull, but a piece of

later) it persists to the same degree. The findings of operation therefore did not account for the rhinorrhea. The openings in the bone could not have been into the frontal sinus.

#### SUMMARY AND CONCLUSIONS

Though not a common condition—11 cases nearly twenty years—continuing rhinorrhea and otorrhea nearly always demand surgical closure of the opening in the dura or the bone, preferably both. Although spontaneous closure of the fistula does occur, it is not common, and it is not safe to delay operation in the hope that such closure may take place. The operation itself is practically free of danger. Death following closure of fistula is due to preexisting intracranial infection—usually one or more abscesses in the brain. The fistula may be closed in several ways: (1) suturing the dural opening; (2) suturing when possible a transplant of fascia over the dural defect; (3) suturing snugly to the overlying tissue a flap of dura or any soft tissue which has been turned over the bony opening; (4) covering the bony opening with bone wax.

Eight of the 11 patients whose cases are included in this report were permanently cured. Two (cases 9 and 10) died subsequently of intracranial infection; in 1 the infection was present at the time of operation, and in the other it appeared subsequently. One patient (case 11) remained unimproved nine months after operation; congenital openings in the dura and bone were found and closed on each side. At the time they were thought to enter the frontal sinuses, but this assumption was incorrect, because there was no benefit. The real fistula therefore was not located.

Usually the location of the fistula is readily determined by the site of a fracture or by an operation at which the opening in the bone and the dura was created. But disclosure of the fistulous tract may be exceedingly difficult, perhaps even impossible, as in case 11. In this case there has been no definite indication even of the side of the fistula. In case 10 the fistula into the middle ear was found only after injecting methylenethionine chloride (methylene blue) through the bulging drum. In this case closure of the fistula in the cartilaginous wall was unsuccessful.

Pneumocephalus with a large unilateral defect in the frontal lobe and complete filling of the ventricular system was present in 2 cases (1 and 2) and was promptly cured after the fistula was closed.

For fistulas through the frontal sinus there are two methods of approach: (1) by elevating the depressed fracture, suturing or covering the

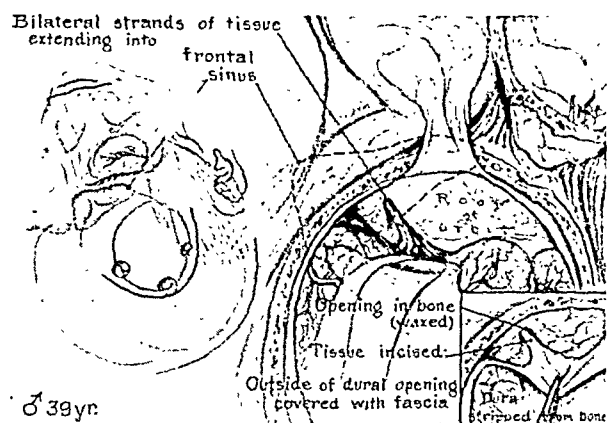


Fig. 8 (case 11).—In this case of spontaneous rhinorrhea a strand of tissue was found running through the dura and the bone and an arachnoidal sheath filled with fluid surrounded this strand of tissue. The same condition was disclosed on the opposite side, but closure of both fistulas did not stop the rhinorrhea. They probably, therefore, did not enter the frontal sinuses, as was hoped at the time of the operation. The fistula causing the rhinorrhea was therefore not found. This is the only case in which the fistula was not located.

temporal fascia was sutured over the opening and treated with 3.5 per cent solution of iodine to stimulate adhesions. The iodine solution was also applied to the opening in the arachnoid. It should be noted that there was evidence of congenital malformation of the left frontal lobe in that the vascular pattern was abnormal—there being two large and tortuous veins running across the outer surface of the lobe from the sylvian fissure to the longitudinal sinus. The unconscious spells were doubtless due to the congenital malformation (on the patient's first admission to the hospital ventriculography showed a normal ventricular system).

After operation the flow of cerebrospinal fluid was unchanged, and at the time of this writing (nine months

defect with fascia and replacing the depressed fracture; (2) if there is no depressed fracture, by exposing the frontal region through a unilateral frontal bone flap with a concealed incision. This is preferable to cutting away the walls of the frontal sinus and leaving an unsightly deformity. If the side of the fistula cannot be determined, the same unilateral exposure is made on the suspected side (suggested by the side of the nose into which the cerebrospinal fluid drains), and if the opening is not found

the same procedure is indicated on the other side later. Two such procedures are preferable to the single large bilateral exposure, which uncovers and usually requires ligation of the longitudinal sinus.

Drainage of cerebrospinal fluid from the nose is not pathognomonic of a fistula into the frontal or the ethmoid sinus but may occur through the mastoid bone into the middle ear and the eustachian tube, as in case 10; this, however, is exceptional.



# PLASMA CELL MASTITIS

## REPORT OF FIVE ADDITIONAL CASES

WILLARD H. PARSONS, M.D.; JOHN C. HENTHORNE, M.D.,  
AND R. LEE CLARK JR., M.D.

VICKSBURG, MISS.

Although plasma cell mastitis is a relatively uncommon disease, it is important because of its clinical resemblance to carcinoma of the breast. The resemblance is so close, as a matter of fact, that in at least half of the recorded cases primary radical mastectomy was performed, on the assumption that the inflammatory swelling was malignant.

This clinical entity (we are among those who accept it as such) was first described under the name plasma cell mastitis by Adair<sup>1</sup> in 1933. Prior to his contribution, as Payne and his associates<sup>2</sup> have pointed out, the condition was described in the German literature under the term mastitis obliterans, and it is possible that it has also been discussed under still other designations. The indolent form of mastitis, described by Bell<sup>3</sup> as pseudotuberculosis, seems to be this same disease. Adair's contribution, however, is so outstanding that the term plasma cell mastitis will probably continue to be favored, especially in the United States.

A description of plasma cell mastitis is included in several recent medical textbooks,<sup>4</sup> and to date some 45 cases have been formally reported in medical literature<sup>5</sup> or have been mentioned in discussions.<sup>6</sup>

From the Departments of Surgery and Pathology, Vicksburg Hospital.

Read before the Section on Surgery, General and Abdominal, at the Ninety-Fourth Annual Session of the American Medical Association, Chicago, June 15, 1944.

1. Adair, F. E.: Plasma Cell Mastitis—A Lesion Simulating Mammary Carcinoma: A Clinical and Pathologic Study with a Report of Ten Cases, *Arch. Surg.* **26**:735-749 (May) 1933.

2. Payne, R. L.; Strauss, A. F., and Glasser, R. D.: Mastitis Obliterans, *Surgery* **14**:719-727 (Nov.) 1943.

3. Bell, E. T.: A Text-Book of Pathology, ed. 3, Philadelphia, Lea & Febiger, 1938, pp. 408-415.

4. (a) Cheatele, G. L., and Cutler, M.: Tumors of the Breast: Their Pathology, Symptoms, Diagnosis and Treatment, Philadelphia, J. B. Lippincott Company, 1931, pp. 298-304. (b) Ewing, J.: Neoplastic Diseases: A Treatise on Tumors, ed. 4, Philadelphia, W. B. Saunders Company, 1940, pp. 547-548. (c) Geschickter, C. F.: Diseases of the Breast: Diagnosis, Pathology, Treatment, Philadelphia, J. B. Lippincott Company, 1943, pp. 161-162.

5. (a) Cutler, M.: Benign Lesions of the Female Breast Simulating Cancer, *J. A. M. A.* **101**:1217-1222

Plasma cell mastitis, according to the various descriptions in the literature, is characterized by a unilateral painless tumor which occurs in parous women. Sometimes mild and evanescent signs of inflammation are present in the course of its development, and occasionally there is watery or a creamy discharge from the nipple. Its most distinctive clinical feature, as already pointed out, is its striking resemblance to mammary carcinoma. It is not usually tender. It is often so adherent to the skin as to produce orange peel dimpling. The nipple is frequently retracted. Finally, the axillary lymph nodes are likely to be enlarged.

The gross lesion of plasma cell mastitis appears as a yellowish brown discoloration of the mammary tissue, often associated with formation of an abscess. The contents of the abscess and of the contiguous ducts are puriform or butter-like. The histologic features of the lesion are: formation of an ulceration of the normal epithelium of the ducts, which is replaced by granulation tissue, whence the term mastitis obliterans; formation of foreign body giant cells, whence the term pseudotuberculosis; and periductal collections of plasma cells and other leukocytes, whence the term plasma cell mastitis. Some authors have reported hyperplasia of the ductile epithelium and intraductal collections of colostrum cells. Others have noted large numbers of eosinophils in the inflammatory exudate, and still others have observed sheaves of fatty acid crystals and other evidences of the presence of lipid substances, such as foamy histiocytes and droplets of fat within the plasma cells.

The 5 specimens from cases of plasma cell mastitis reported on in this communication were collected from a total of 1,500 specimens from

(Oct. 14) 1933. (b) Rodman, J. S., and Ingleby, H.: Plasma Cell Mastitis, *Ann. Surg.* **109**:921-930 (June) 1939. (c) Miller, J. K.: Plasma Cell Mastitis: A Pathologic Entity, *Am. J. Surg.* **43**:788-793 (March) 1939. (d) Cromar, C. D. L., and Dockerty, M. B.: Plasma Cell Mastitis, *Proc. Staff Meet., Mayo Clin.* **16**:775-783 (Dec. 3) 1941. (e) Adair.<sup>1</sup> (f) Ewing.<sup>4b</sup>

6. (a) Moore, J. J., in discussion on Cutler.<sup>5a</sup> (b) Frank, L. W., in discussion on Rodman and Ingleby.<sup>5b</sup>

female breasts studied during the past six and a half years from the services of the Vicksburg Hospital and from other sources in Mississippi. Clinical data are complete for only 2 of the cases, but reports on the other 3 are included to give some index of the general incidence of this condition. As several authors have pointed out, any review of a reasonably large number of cases of disease of the female breast is likely to reveal a few cases of plasma cell mastitis.

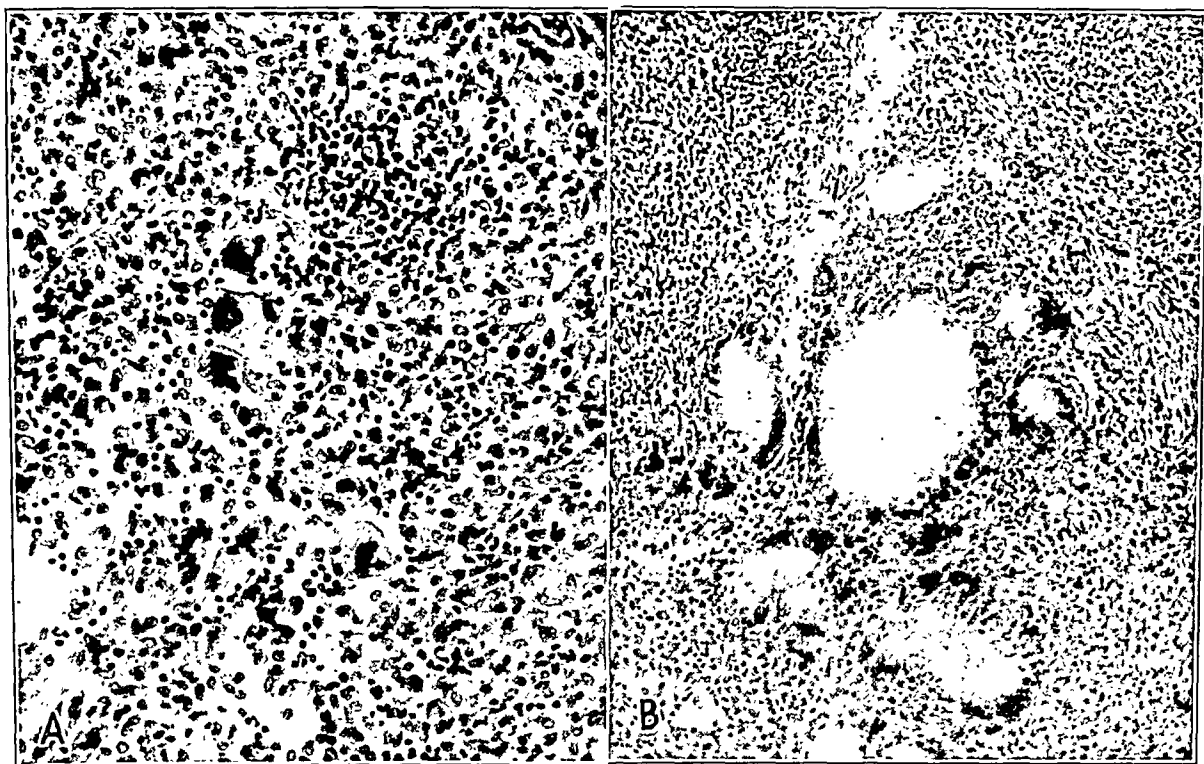
#### REPORT OF CASES

CASE 1.—Mrs. L. E. A., a white woman aged 43, was admitted to the Vicksburg Hospital in the surgical service of one of us (W. H. P.) on Jan. 26, 1940. On

position, there was a definite orange peel dimpling of the skin, which was slightly reddened. Palpation over this area revealed an underlying tumor, which was 2.5 cm. in diameter and was attached to the skin; it was not tender. The axillary lymph nodes could not be palpated. The physical examination otherwise gave essentially negative results:

Urinalysis revealed no abnormality. The hemoglobin content was 15.3 Gm. (Sahli). The erythrocytes numbered 4,640,000 and the leukocytes 16,700 per cubic millimeter. The neutrophilic percentage was 68. Flocculation tests for syphilis gave negative results, and roentgenologic examination of the chest for possible metastases revealed no abnormality.

Radical mastectomy, on the right side was performed Jan. 27, 1940, with the patient under cyclopropane-ether anesthesia, on the assumption that the lesion in



Plasma cell mastitis. *A*, inflammatory exudate containing foreign body giant cells and plasma cells (hematoxylin and eosin;  $\times 200$ ). *B*, clear areas, which are evidently produced by sheaves of fatty acid crystals, surrounded by giant cells (hematoxylin and eosin;  $\times 115$ ).

January 3, while bathing, she had noticed a "lump" in the right breast. There had been no pain or discomfort at any time, but in the next two weeks the mass had become larger and the skin over it had become slightly reddened.

The patient's family history was not significant. Her cervix uteri had been cauterized at the Vicksburg Hospital in July 1939, and her appendix had been removed elsewhere sixteen years before. She had been married twice. The second marriage was without offspring, but she had had three children by her first husband, and during this marriage she had had a therapeutic abortion, the details of which were unknown.

Objectively both breasts seemed equal in size, but in the right breast, just below the nipple in the 6 o'clock

the breast was malignant. The pathologic report was as follows (J. C. H.):

The specimen consisted of a mammary gland removed by radical mastectomy together with the pectoral muscles and the axillary lymph nodes. Beneath the nipple in the 6 o'clock position was an abscess 3 cm. in diameter filled with yellowish brown, semiliquid, putty-like material. The shaggy brownish discoloration of the wall of the abscess extended into the contiguous mammary tissue and skin. The ducts of the remainder of the breast were distended with inspissated brown fluid, which was easily expressed. The axillary nodes were soft and gray and were enlarged to a diameter of 1.5 cm.

Histologic examination revealed the wall of the abscess to be lined with granulation tissue infiltrated with a variety of leukocytes, including plasma cells, neutrophils and giant cells of the foreign body type (*A* of the figure). In several areas there were collections of clear paraffin-like material, which on closer inspection presented needle-shaped crystals arranged radially around the periphery. These clear areas were surrounded by giant cells (*B* of the figure). Elsewhere in the tissues surrounding the abscess periductal fibrosis and infiltration of leukocytes were observed. Colostrum cells were found in a few of the ducts, but hyperplasia of the epithelium was not notable. The axillary lymph nodes showed fatty changes and dilatation of the sinusoids.

The original diagnosis was pseudotuberculosis with formation of an abscess and diffuse comedomastitis. Later, when the contributions to the literature on plasma cell mastitis came to our attention, this term was substituted for pseudotuberculosis, and the same change in terminology was made in cases 3, 4 and 5, which had already been observed.

The postoperative course was uneventful, and the patient was discharged on the thirteenth day after operation. The wound healed by primary intention.

The patient has been observed on several occasions since her discharge. On Dec. 4, 1940 she was delivered of a normal child, and on March 14, 1941 a calculus was removed from the left kidney. She was last seen April 8, 1944, for symptoms referable to the menopause. No changes were observed in the remaining breast during pregnancy or menopause.

CASE 2.—Mrs. W. J. B., a white woman aged 42, was first seen by one of us (R. L. C.) on Aug. 15, 1940. She had had pain in the right nipple for the past three years, and a month before she was admitted to our service she had discovered a tumor in this location. The tumor had been slightly painful from the time of its discovery, and at the time of consultation soreness extended into the right axilla.

The patient was married and had two children, the youngest of whom was 10 years old. The left ovary and the appendix had been removed in 1922 and the uterus, tubes and right ovary in 1932. For the past four or five years she had had recurrent attacks of pyelitis, the last of which had occurred about two months before consultation.

Objectively the breasts, which were pendulous, were equal in size. In the right breast an area of erythema, about 3 cm. in diameter, extended toward the 2 o'clock position from the edge of the nipple, which was retracted. Underlying this area there was a dense, slightly irregular, moderately tender tumor of approximately the same size. The axillary lymph nodes were not palpable.

Urinalysis revealed no abnormalities, and flocculation tests for syphilis gave negative results. The hemoglobin content was 16 Gm. (Sahli). The erythrocytes numbered 4,880,000 and the leukocytes 9,950 per cubic millimeter. The neutrophilic percentage was 67.

The involved portion of the right breast was removed on Aug. 20, 1940 with the patient under anesthesia induced with intravenously administered pentothal sodium, and was described as follows (J. C. H.):

The specimen consisted of a lobule of fibrous mammary tissue measuring 2.5 by 2 by 2 cm. The cut surface contained an area of shaggy brown discoloration, and putty-like material could be expressed from the ducts.

Histologic examination revealed periductal accumulation of leukocytes, including many plasma cells and a

moderate number of foreign body giant cells. Exudative process had obliterated the architecture of the lobule. Colostrum cells were observed in several of the dilated ducts.

The diagnosis was plasma cell mastitis.

The patient was dismissed from the hospital the day after operation. Observation on Sept. 13, 1940 showed the wound well healed and the breast apparently normal. The local findings were the same on Oct. 3, 1940. The patient at this time was suffering from acute tonsillitis. Treatment was carried out elsewhere, and tonsillectomy at a later date was advised, but the advice had not been accepted up to the time of this report.

The patient was again seen Dec. 10, 1940, for digestive disturbance. The breast revealed no abnormalities. On March 20, 1941, five months after removal of the mammary tumor, she presented herself complaining of swelling of the right breast, discharge from the nipple and pain extending down the right arm to the elbow. Examination showed the breast to be tender and inflamed in the region of the scar, and palpation revealed a small swelling just beneath the incision. When the affected area was incised, a small amount of thick yellow pus was evacuated. All evidences of inflammation had subsided within two weeks.

When the patient was last seen, on June 11, 1944, she had had no further difficulties referable to the breast.

CASE 3.—The biopsy specimen in this case was obtained on March 10, 1938. Histologic examination revealed a periductal inflammatory reaction, including fibrosis, leukocytic infiltrations and collections of blood pigment. It was thought that the lesion represented an inflammatory change, such as might result from trauma.

On April 12, 1938, in submitting for study the entire mammary gland and a portion of the pectoralis major muscle, the surgeon wrote that the patient had continued to have symptoms and that the lesion had become adherent to the skin and had penetrated the fascia of the pectoral muscle. He was naturally concerned over the possibility of cancer. Nothing to suggest this diagnosis, however, was found in the specimen, which revealed plasma cells, foam cells and foreign body giant cells. The original diagnosis of pseudotuberculosis was later changed to plasma cell mastitis.

CASE 4.—The biopsy specimen in this case was obtained on Sept. 21, 1939. Examination revealed a foreign body reaction, evidently against material extravasated from the ducts. A diagnosis of pseudotuberculosis (later plasma cell mastitis) was made.

CASE 5.—The biopsy specimen in this case was obtained on Oct. 30, 1940. The diagnosis was pseudotuberculosis (later plasma cell mastitis) associated with comedomastitis.

#### COMMENT

The clinical features of the cases of plasma cell mastitis reported here duplicate those common to most of the other recorded cases. In case 1, for instance, the resemblance to carcinoma of the breast was embarrassingly close, and the associated leukocytosis observed in this case has also been recorded by Geschickter.<sup>4c</sup> In case 2 the lesion was more definitely suggestive of an inflammatory process, although it was only moderately tender, and the nipple was retracted.

The discharge from the nipple in this case was similar to the discharge in other recorded cases, though in this instance it was part of the recurrent and not of the primary lesion.

Some features of this disease have not previously been reported, including recurrence of the lesion, which was observed in cases 2 and 3, and diffuse comedomastitis, which coexisted in the excised portions of the mammary glands in cases 1 and 5. It is possible that material high in lipid content may be contributed to the inflammatory area as the result of the presence of comedomastitis.

In case 2, the patient had badly diseased tonsils, and the speculation is advanced that the focal infection may have contributed to the development of the mastitis, because in another case of indolent mastitis observed by one of us (R. L. C.) the patient continued to have trouble with the breast until tonsillectomy was carried out, after which, without other therapy, the mastitis promptly subsided.

It is interesting that in case 1 the patient went through a normal pregnancy in the same year that her breast was removed without the development of mastitis in the remaining breast. It is also interesting that in case 2 the patient had been castrated five years before the onset of symptoms referable to the breast and the course of the plasma cell mastitis covered three years, which is an unusually prolonged time for this condition. The apparent difference in the endocrine constitution in the 2 cases seems worthy of comment.

#### SUMMARY AND CONCLUSIONS

A study of 5 cases of plasma cell mastitis, which are reported herewith, leads us to agree with other observers that this disease, which is a periductal inflammatory reaction caused by the extravasation of material from the ducts into the periductal fibrous tissue, is a true clinical entity. The morphologic characteristics of the lesion apparently depend on the lipid character of the ductal contents.

The speculation is advanced that if comedomastitis, which was associated with the plasma cell mastitis in 2 of the reported cases, exists prior to the extravasation of material from the ducts it may be responsible for the large quantity of material high in lipid content in the inflammatory area. Focal infection is also suggested as one of several possible causes of ulceration of the ducts and of extravasation of their contents.

#### ABSTRACT OF DISCUSSION

DR. WARREN H. COLE, Chicago: Dr. Parsons has called attention to the marked similarity of plasma cell mastitis to carcinoma. I should like to emphasize the

difficulty in distinguishing plasma cell mastitis from fat necrosis in certain cases. Obviously, fat necrosis exhibiting large areas of liquefied fat bears little resemblance to plasma cell mastitis as described eleven years ago. However, in fat necrosis with minimal liquefaction of fat the histologic features may be identical. Although not appreciably emphasized previously, a study of sections from fat necrosis which are well advanced toward resolution will show heavy infiltration of plasma cells, indicating that the plasma cell itself is not specific for the lesion under discussion. Likewise, lymphocytic infiltration, giant cells and moderate epithelial hyperplasia will also be encountered in fat necrosis. It is true that the histologic resemblance to carcinoma is different in the two lesions, in so far as plasma cell mastitis resembles comedo carcinoma, whereas the hyperplasia in fat necrosis resembles a medullary type of carcinoma. It is proving extremely difficult to classify a case recently observed at the Illinois Research Hospital. This patient was 41 years of age. She had four children, the youngest of whom was 17 months old. The mass in the breast was only of six weeks' duration and for the first two or three weeks showed the typical mild inflammatory reaction encountered in plasma cell mastitis. Sections showed a moderate number of plasma cells along with the other features of mild inflammation, including numerous giant cells. All of three cultures of liquefied sebaceous-like material and other parts of the lesion gave negative results. In most cases of plasma cell mastitis, as reported in the literature, there is mild evidence of fat necrosis, as suggested by fat globules in the giant cells and plasma cells. It appears that in both lesions fat necrosis may be the most important factor, thereby explaining the inflammatory reaction observed histologically. In fat necrosis trauma can be considered as the initial trigger mechanism, which, however, is lacking in plasma cell mastitis. Although, occasionally, cultures are reported as giving positive results in plasma cell mastitis, there is no conclusive evidence that a pathogenic bacterium is the cause. Nevertheless, the inflammation is obviously secondary to some mechanism. If it is infection the cause must be either an extremely mild pathogenic bacterium or possibly a virus. The multiplicity of virus infections, including such diseases as venereal lymphogranuloma, which exhibits inflammation frequently progressing to suppuration, is sufficient evidence to support this possibility. The fact that fat necrosis may be the chief factor responsible for the inflammatory reaction in both diseases is not new, since Ewing in Adair's original article (1933) stated: "It may therefore be concluded that while bacterial infection is probably a necessary factor in the process, its influence is less prominent than the chemical effect of decomposing fatty material."

I thought that my idea on the prominent role which the chemical effect of decomposing fat material assumes in plasma cell mastitis was new, but my recent discovery of this statement by Ewing indicates that he had that point in mind at the time of the original description.

DR. R. L. SANDERS, Memphis, Tenn.: The condition described is rare. Its chief interest lies in its resemblance to carcinoma. The fact that the essayists have observed plasma cell mastitis in 5 of 1,500 pathologic specimens indicates that, despite its rare incidence, it should be kept in mind in the differential diagnosis. Clinically, plasma cell mastitis may be divided into two phases: acute and residual. The acute phase, which presents the signs and symptoms of a diffuse inflammatory lesion radiating from the nipple, is frequently sudden in onset, though usually it is not severe and

does not proceed to formation of an abscess. Instead, after several days the acute symptoms subside, and occasionally the condition will clear up completely. In many cases after subsidence of the acute manifestations there remains a firm, often irregular tumor which may present all the signs of carcinoma. After this stage is reached, improvement takes place so slowly as to be imperceptible. If the patient is seen during the acute stage, the distinction between an inflammatory and a malignant lesion should present little difficulty. After this time one must rely chiefly on the history of an acute inflammation which has subsided. Carcinoma is progressive and, even though accompanied by inflammation, continues to spread and become increasingly severe. A discharge from the nipple is also indicative of plasma cell mastitis, and of additional diagnostic value is the fact that the condition generally develops in the nonlactating breast. The diagnosis is not always easy, as the history may be indefinite and the clinical picture may vary from the usual pattern. This is illustrated in the first case presented by the essayists, in which the patient had no pain, discomfort or discharge from the nipple. Adair stated that in 6 of the 10 cases which he reported the tumor was regarded as malignant by several men with extensive experience in diagnosis of cancer. Of 24 cases reported by Cromar and Dockerty at the Mayo Clinic, a diagnosis of cancer was made in 17. In some cases the diagnosis may be established by biopsy, yet here again there is much room for error because of the varied histologic picture. In only 2 of the 24 cases at the Mayo Clinic was the pathologist's diagnosis plasma cell mastitis. During the acute stage, only conservative treatment is indicated. Once the symptoms have subsided, however, local excision of the tumor is advisable. The prognosis in these cases is unknown; since the lesion may be almost indistinguishable from carcinoma histologically as well as clinically, one may assume that it is of the precancerous type. Every attempt should be made to establish the diagnosis in order to avoid a radical operation; if this cannot be done with certainty, then one should not hesitate to perform a total mastectomy. It is better to follow this course and perhaps accept credit for the cure of a supposed carcinoma than to withhold the total operation on the slight chance that the condition might not be malignant.

DR. FRANK E. ADAIR, New York: The subject has been thoroughly discussed, but microscopic slide necessary to show why pathologists have been misled by the pathologic picture. I am delighted that Parsons has contributed his 5 cases to the literature, because I have become discouraged wondering whether or not the subject was going to die slowly. Adair will show why pathologists have difficulty in making diagnosis. The plasma cell denotes chronicity, and in cases of plasma cell mastitis the whole field is infiltrated with many of these plasma cells, in which the nucleus is eccentrically placed. The histologic change the ducts have added to the great confusion of pathologists—the people who seemed to have the greatest interest and who sent to me for slides after I reported my cases eleven years before the present report. This is a great heaping up of the lining cells of the ducts and many pathologists who wrote to me for the slides told me that they had always called this condition comedo carcinoma because the cells lining the ducts were piled up eight and ten rows high. That is the reason, I think, why there has been a good deal of question in the minds of some of the pathologists as to plasma cell mastitis.

DR. JOHN C. HENTHORNE, Vicksburg, Miss.: Cole's comments about the relation of fat necrosis to plasma cell mastitis are pertinent, because after all the conditions seem to be the result of extravasation of lipid material into the fibrous tissue. One lesion is produced by extravasation of fat from the interstitial tissue and the other, plasma cell mastitis, may possibly be produced by extravasation of lipid material from the contents of the ducts. Whether or not plasma cell mastitis is produced by an infectious agent has not been investigated, possibly because the material after it has been excised from the breast is not suitable for inoculation of animals by the time the diagnosis is established. Inoculation of animals with suitable material should be done, but it is my opinion that most of the authors who have contributed to the subject have the impression that an infectious agent is not responsible for the disease. Dr. Sanders' discussion of the clinical features of plasma cell mastitis is especially interesting, since he was able to think back over his experience and recall certain cases of mammary tumor that might fall into this category.

## ROENTGEN FEATURES OF CHRONIC TUBERCULOUS PERITONITIS

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Most authorities agree that the clinical diagnosis of tuberculous peritonitis is difficult.<sup>1</sup> The roentgenologic features of this disease were reported by Ritvo<sup>2</sup> and Soper<sup>3</sup> in their studies of the small intestine. Schatzki<sup>4</sup> likewise found an abnormal small intestinal pattern accompanying this disease. Since his investigation particular attention has been paid at the Massachusetts General Hospital to the possibility of establishing by roentgen examination a preoperative diagnosis; the condition of 3 patients who were admitted to the hospital subsequently was correctly diagnosed by the examining radiologist. The present paper presents these 3 cases and 3 additional proved cases of tuberculous peritonitis in which complete roentgenologic study of the large and the small bowel revealed certain characteristics.

Infection of the peritoneal surfaces with the tubercle bacillus may be divided into two main types, *acute* and *chronic*. The acute type may be further divided into two forms: (a) acute miliary tuberculosis of the peritoneum as part of a widespread hematogenous dissemination, the changes in the peritoneum being overshadowed by the primary process, and (b) acute localized peritonitis with involvement of a few mesenteric glands and the adjacent peritoneum. In a small percentage of cases of the localized type of peritonitis, owing to lowered resistance of the host or to high virulence of the organism, the tubercles break

down and invade the greater part of the peritoneum, giving rise to *chronic* tuberculous peritonitis.

Acute localized peritonitis, which is not always recognized clinically, is usually found in children. No roentgenologic studies of this form were reported in the literature which I reviewed. In the majority of instances the process remains localized and results in caseation, fibrosis and calcification. Gibson<sup>5</sup> studied a group of 200 children and found 19 to have calcification of the abdominal lymph nodes, in 5 of whom there was indisputable proof of tuberculosis elsewhere. Thorough examination of the remaining 14 did not reveal the primary focus. He concluded that this disease should be suspected in children who give a positive reaction to the tuberculin test, whose normal growth has been interrupted and who have vague abdominal symptoms. Frank<sup>6</sup> expressed the opinion that tuberculous peritonitis is more common than is generally recognized. He found local peritoneal involvement in the majority of the 29 cases of tuberculous enteritis which he studied at autopsy. It is the experience of most radiologists who view a large number of roentgenograms of the abdomen that the finding of calcified lymph nodes is fairly frequent.

### PATHOLOGY

Chronic tuberculous peritonitis is considered by pathologists to be a secondary infection in all cases.<sup>7</sup> Crawford and Sawyer,<sup>8</sup> in a study of 1,400 autopsy records, found 966 cases in which some form of tuberculosis was present. Of the 966 there were 645 cases of intestinal tuberculosis, in 73 of which peritonitis was a complication. In the majority of the 73 cases peritonitis was

5. Gibson, C. B.: Calcified Abdominal Lymph Nodes, *Am. Rev. Tuberc.* **29**:447-460, 1934.

6. Frank, L. W.: Tuberculous Peritonitis, *Am. Rev. Tuberc.* **36**:279-282, 1937.

7. (a) Boyd, W.: Tuberculous Peritonitis, in *Textbook of Pathology*, Philadelphia, W. B. Saunders Company, 1936, pp. 623-624. (b) MacCallum, W. G.: Tuberculous Peritonitis, in *A Textbook of Pathology*, ed. 6, *ibid.*, 1936, pp. 652-654.

8. Crawford, P. M., and Sawyer, H. P.: Intestinal Tuberculosis in 1,400 Autopsies, *Am. Rev. Tuberc.* **30**:568-583, 1934.

From the Department of Radiology, Massachusetts General Hospital.

1. (a) Blake, J. A.: Tuberculous Peritonitis, in *Nelson's Loose Leaf Surgery*, New York, Thos. Nelson & Sons, 1941, vol. 5, chap. 1, pp. 35-41. (b) Pincoffs, M. C., and Boggs, T. R., in Christian, H. A., and Mackenzie, J.: *Oxford Medicine*, New York, Oxford University Press, 1921, vol. 3, pt. 2, pp. 250-268. (c) Stein, I. F.: Oxygen Pneumoperitoneum in the Diagnosis and Treatment of Tuberculosis of the Genitalia, Intestines and Peritoneum, *Surg., Gynec. & Obst.* **58**: 567-577, 1934.

2. Ritvo, M.: Roentgen Diagnosis of Lesions of the Jejunum and Ileum, *Am. J. Roentgenol.* **23**:160-169, 1930.

3. Soper, H. W.: Roentgen-Ray Diagnosis of Lesions of the Small Intestine, *Am. J. Roentgenol.* **22**: 107-119, 1929.

4. Schatzki, R.: Small Intestinal Enema, *Am. J. Roentgenol.* **50**:743-751, 1943.

thought to have followed perforation of ulcers and in a lesser number, to have been due to spread along the lymphatics to the mesenteric lymph nodes, with subsequent generalized peritonitis; in a few, not associated with intestinal ulceration, it was ascribed to general hematogenous miliary tubercles. Two forms of pathologic change in the peritoneal tissue, named appropriately "wet" and "dry," have been recognized and described.<sup>9</sup> It is to be remembered, however, that these forms are not distinct entities, but overlap somewhat, so that both forms may occur simultaneously in different portions of the same abdomen.

Wet, or exudative, peritonitis usually occurs in the early stages of the disease. The peritoneal surfaces are covered with numerous small miliary tubercles, which are also scattered over all the organs. Each tubercle is surrounded by an area of inflammation and serous exudation. These areas of exudation give rise to an accumulation of fluid, often enormous in amount. In addition to these changes the omentum may be infiltrated and thickened, frequently with the formation of hard masses.

In dry, or adhesive, peritonitis, exudation is at a minimum. Fibrin forms between the visceral and the parietal layer of the peritoneum and even between the visceral layers of the peritoneum. Boyd<sup>10</sup> has shown by selective staining that this interlayer is fibrin rather than fibrous tissue. The end result of this process is a solid matting together of the abdominal viscera. It is this biologic response, the walling off of the infection, that makes a roentgen diagnosis possible.

Chronic tuberculous peritonitis, therefore, may develop by any one of three routes: (1) perforation, (2) lymphatic channels or (3) the blood stream. The relation between tuberculous peritonitis and tuberculous salpingitis is not clearcut. Some investigators have stated the belief that in the female the fallopian tubes are the most frequent source of infection<sup>11</sup>; others have expressed the opinion that the tubes are secondarily rather than primarily involved.<sup>7b</sup> Since the sex incidence of tuberculous peritonitis is about equal, it seems illogical to consider the fallopian tubes as a primary source of the infection.<sup>12</sup>

9. Van Antwerp, L. D.: Tuberculous Peritonitis in Children, *New England J. Med.* **217**:995-998, 1937. Blake.<sup>1a</sup> Boyd and MacCallum.<sup>7</sup>

10. Boyd, W.: Tuberculous Peritonitis, in *Surgical Pathology*, Philadelphia, W. B. Saunders Company, 1942, pp. 364-366.

11. Hertzler, A. E.: Diseases of Peritoneum, in Christopher, F.: *Major Surgery*, Philadelphia, W. B. Saunders Company, 1943, pp. 1071-1072. Boyd (footnotes 7a and 10).

12. Olcott, C. T., and Paccione, D.: Tuberculous Peritonitis, *Am. Rev. Tuberc.* **28**:27-61, 1933.

## INCIDENCE, AGE AND RACE

The incidence of tuberculous peritonitis vary according to the type of institution in which the study is made. At the Massachusetts General Hospital in the past five years only 17 cases were found in a total of 182,329 admissions. In the diagnosis was made on the basis of observations made by biopsy, smear, culture or guinea pig inoculation; in the remaining 3 it was made on clinical grounds alone. Bircher<sup>13</sup> in 1907, reviewing reports of 14,000 autopsies collected from the literature, found an incidence of 3.5 per cent. Olcott and Paccione<sup>12</sup> in 1938 reported 10 cases of tuberculous peritonitis (0.13 per cent) in a total of 65,000 admissions to the New York Hospital. Undoubtedly in an institution devoted to the care of tuberculous patients the incidence of tuberculous peritonitis would be higher than in a general hospital.

The age of the patient is of clinical significance. Children and young persons are most frequently affected. All writers agree, however, that tuberculous peritonitis may occur at any time during the life span.

The relation of race to incidence is difficult to evaluate. Reports that Italians<sup>14</sup> and Negroes<sup>15</sup> are particularly susceptible are unsubstantiated, since such reports ignore the socioeconomic factors, which are probably more vital in determining susceptibility than race.

## CLINICAL MANIFESTATIONS

The protean manifestations of tuberculous peritonitis can be appreciated from the classic description of Pincoffs and Boggs.<sup>1b</sup> Ascites, usually insidious and painless in its onset, is almost always present at some stage of the disease and due to the rapid formation of tubercles over the peritoneal surface. Consequently it is more common in the early stages and will recur when chronic caseous tubercles break down and further extension of the disease occurs. A wide variation in the symptoms in the gastrointestinal tract exists, and none or many may occur. Abdominal pain, loss of appetite, occasional nausea and vomiting, slight constipation, and a sensation of fulness in the abdomen are the most frequent complaints. The pain may vary in its location and its severity, but all authorities have stressed the mildness of the symptoms. A low grade fever

13. Bircher, E.: Die chronische Bauchfelltuberculose: Ihre Behandlung mit Roentgenstrahlen, *Inaug. Dissert.*, Aarau, G. Keller, 1907; cited by Olcott and Paccione.<sup>12</sup>

14. Cabot, R. C.: *Differential Diagnosis*, Philadelphia, W. B. Saunders Company, 1914, vol. 2, p. 103. Olcott and Paccione.<sup>12</sup>

15. Barrow, D. W.: Tuberculous Peritonitis, *South. M. J.* **36**:646-650, 1943.



ily elevations of temperature and occa-  
hills is an almost constant finding. The  
lood cell count may be slightly elevated,  
rule it is within the normal range.<sup>12</sup>

cal examination will usually reveal a thin,  
ed person in the younger age group, with  
ded abdomen. Soft doughy masses may  
able within the abdomen; these are due  
tation and thickening of the omentum and  
action into lumps by the formation of ad-  
10

rculosis elsewhere is not a constant feature.  
f 109 cases, Olcott and Paccione<sup>12</sup> found  
sy no infection outside the peritoneal cavi-  
ne remaining cases tuberculosis was found,  
of frequency, in the intestines, the fallo-  
pes and the lungs. Barrow<sup>15</sup> found clini-  
at only 1 of 5 patients had active tubercu-  
ewhere. In the 6 cases presented here no  
uberculosis was found except in the peri-

#### ROENTGEN FINDINGS

e wet form of tuberculous peritonitis the  
entgenogram taken in an early stage of  
ease usually shows ascites with a low  
leus. The characteristics of abdominal  
have been well described by Laurell<sup>16</sup>  
ers.<sup>17</sup> A diffuse haziness of the abdomen  
with obliteration of the outlines of the  
nscles and the subperitoneal fat. The  
ntestine, which is usually filled with gas,  
to be floating free in the abdomen. The  
gm is elevated. These features are not  
ive and may occur in a number of other  
; which are characterized by an accumula-  
peritoneal fluid. However, the presence  
es in a young person, with a history of  
veral weeks or months before, should sug-  
possibility of tuberculous peritonitis, and  
study of the colon and the small bowel  
be undertaken.

ie dry form of tuberculous peritonitis the  
lm demonstrates ileus alone. Here again  
re no pathognomonic signs. The small  
e is drawn up high in the abdomen, but  
sition is difficult, in fact almost impossible,  
rmine without the aid of a contrast sub-

roentgenoscopic and roentgenographic  
ation of the colon after a barium sul-  
nema is more informative. In my

urell, H.: Roentgenologic Signs of Abdominal  
: Roentgen Diagnosis of Peritonitis, *Acta*  
5:63-104, 1926; A Contribution to the Roent-  
cal Differential Diagnosis in the Presence of  
uid in the Abdomen, *ibid.* 16:424-425, 1935.  
ascesco, A.; David, N., and Stanesco, C.:  
n Image of Free Intraperitoneal Fluid in Peri-  
*Presse méd.* 27-28:310-312, 1940.

cases it revealed no intrinsic lesions, but the  
possibility of tuberculosis of the ileocecal region  
should always be borne in mind, as it may be  
the origin of tuberculous peritonitis. In tubercu-  
lous peritonitis the intestinal wall is rigid, with  
areas of narrowing and areas of dilatation, and  
the bowel is not freely movable in the peritoneal  
cavity. These features are present even in the  
wet form, because the two forms overlap and  
some degree of adhesive peritonitis is present in  
all cases. Roentgenograms taken after evacu-  
ation of the barium sulfate will confirm this im-  
pression. If the intestine is normal a completely  
empty transverse colon will tend to occupy a  
position lower in the abdomen than it did when  
the distending mass of barium sulfate was present  
within its lumen. In tuberculous peritonitis there  
is little or no change in the position of the trans-  
verse colon after evacuation of barium sulfate.  
Also on the film taken after the barium has been  
evacuated adhesive bands retracting the intesti-  
nal wall may sometimes be seen.

Of greatest value is the study of the small  
bowel, which may be made by serial films or by  
injecting a barium sulfate mixture directly into  
the small bowel, after the method of Schatzki.<sup>4</sup>  
The first abnormality noted is the rapid passage  
of barium through the small bowel, only about  
six minutes being required for its transit. A  
cause for this rapid movement of barium is  
that peritoneal irritation results in spasm of  
the muscularis mucosae, as explained by  
Golden.<sup>18</sup> Rigidity and fixation of the loops  
of small intestine are marked, and extended  
observation will show no change in their posi-  
tion. The small intestine is shorter, and it  
occupies a smaller space than normal. Pincoffs  
and Boggs<sup>1b</sup> observed at postmortem examina-  
tion that the small intestine is frequently pulled  
to the right. My studies did not confirm this  
point but did demonstrate displacement upward  
as a rule. Occasionally a few loops may be low  
down in the pelvis, particularly in female patients  
with accompanying tuberculous salpingitis.  
Although the small intestine is matted together,  
the intervening spaces between the barium-  
filled loops of small bowel are slightly widened  
and irregular, owing to the interspersed  
of fluid and fibrin between the peritoneal surfaces.  
No definite arrangement of the loops of small  
bowel was noted, other than that they were  
irregular and bizarre, as observed also by Ritvo<sup>2</sup>  
and Soper.<sup>3</sup> Abnormal segmentation of the  
barium-filled bowel, indicating a disturbance in  
intestinal motility, was seen in 3 of my patients.

18. Golden, R.: Disturbances in Small Intestinal  
Motility, paper read at the meeting of the New  
England Roentgen Ray Society, May 19, 1944.



## DIFFERENTIAL DIAGNOSIS

The diagnostic points which I have enumerated are fairly conclusive for a generalized chronic adhesive process in the peritoneum. Several diseases other than tuberculous peritonitis may give a somewhat similar roentgenographic appearance and should be considered in establishing the diagnosis.

Adhesive peritonitis with ascites will occur with carcinomatous peritonitis. This is frequently secondary to carcinoma in the gastrointestinal tract or in the female genital organs. A primary malignant growth in the gastrointestinal tract will be demonstrated with the routine barium sulfate enema, and the bimanual pelvic examination should disclose malignant disease of the lower part of the genital tract. In ovarian carcinoma, which usually occurs in persons in an older age group, a mass in the pelvis may be seen clearly, displacing the viscera upward. On the other hand, in tuberculous salpingitis, when it accompanies peritonitis, the pelvic mass tends to bind down the lower loop of ileum. Lymphoma of the intestine with involvement of mesenteric lymph nodes is generally more localized. The finding of disease elsewhere in the body will aid in the differential diagnosis. Theoretically, primary colloid carcinoma of the peritoneum would be impossible to distinguish from chronic tuberculous peritonitis. Unfortunately no case of this disease was available for this study.

In ovarian or paraovarian cyst a large mass will be visible, displacing the viscera upward. The adhesive factors, however, are absent. Retroperitoneal hernia of the bowel might cause the segments of intestine to be drawn together but would not cause change in motility.

Other diseases which will produce ascites should be considered, including heart disease, cirrhosis or cancer of the liver, renal disease and pyeloplebitis, but the clinical features and the chemical picture of the blood will be different. Roentgenologically the signs of adhesion in the large and small bowel will be absent.

## REPORT OF CASES

CASE 1.—The changes in the small intestine were noted on review of the roentgenograms, after the diagnosis had been established by exploratory laparotomy and biopsy. This case was reported by Schatzki.<sup>4</sup> It is presented here in greater detail, since it initiated subsequent investigation of tuberculous peritonitis.

V. R., a 48 year old Polish man, was admitted to the hospital in November 1942, with the complaint of loss of weight and abdominal pain of four months' duration.

*History.*—The patient suffered with vague abdominal pain midway between the xiphoid process and the

umbilicus, occasional nausea but no vomiting. He lost 20 pounds (9 Kg.) in three months; there was evidence of diarrhea or tarry, bloody or clay-colored stools. He had been inconvenienced by nocturia (urinating twice nightly) for several years, but there were no other urinary symptoms.

*Physical Examination.*—The patient was a well developed man, showing evidence of recent loss of weight but he was in no acute distress. His skin was dry hanging in folds; he had a few carious teeth. Pulse was regular, and his blood pressure was systolic 110 and 102 diastolic; his heart was not enlarged to percussion. The abdomen was tense, with a questionable mass in the right lower quadrant; there was gaseous distention. The right lobe of the prostate was harder than normal but not enlarged. His temperature while he was in the hospital varied between 98° and 100° F., reaching 104° on one occasion.

*Laboratory Examination.*—The urine was normal. Examination of the blood revealed a hemoglobin content of 74 per cent, 4,500,000 red cells and 10,300 white cells, with polymorphonuclear cells 64 per cent, lymphocytes 28 per cent and monocytes 8 per cent. The stool gave a negative reaction to the guaiac test. Chemical examination of the blood showed sugar 82 mg. per hundred cubic centimeters, and nonprotein nitrogen 22 mg., chlorides 96.9 mg. per liter, carbon dioxide 26.8 mg. per liter, albumin 1.8 Gm. and globulin 7.3 Gm. per hundred cubic centimeters, with an albumin-globulin ratio of 0.25. The prothrombin time was thirty-one seconds (normal was twenty-seven seconds). The reaction of the blood to a Hinton test was negative.

*Roentgen Examination.*—A roentgenogram of the chest showed linear areas of atelectasis of the diaphragm on both sides, but it was otherwise normal. A series of roentgenograms of the gastrointestinal tract and films taken after an enema of the small intestine and a colonic enema gave negative results.

*Exploratory Operation* (Dec. 8, 1944).—The peritoneum was tremendously thickened, as if involved in a chronic process, and there were many small white spots on it of a type that could be associated with chronic tuberculosis. Histologic study of a surgical specimen revealed caseous tuberculosis.

In view of the pathologic diagnosis, the films taken after an enema of the small intestine were reviewed, and several suggestive factors became apparent. The small intestine filled easily; the intestinal loops were grouped with too great regularity, and the length of the small intestine was perhaps unduly short. The lower border of the small intestine appeared somewhat smooth and higher than usual. No intrinsic lesions, however, were evident. The combination of these findings should have indicated chronic intraperitoneal disease, such as tuberculous peritonitis.

CASE 2.—The diagnosis was suggested by the roentgenographic appearance of the large bowel and was substantiated by serial films of the small bowel taken one hour after roentgenologic diagnosis was confirmed by peritoneoscopy and biopsy.

T. G., a 45 year old Syrian man, was admitted to the hospital in January 1944, with a constant heavy sensation in the epigastrium of several months' duration, unassociated with pain or gas.

*History.*—The patient suffered with constant epigastric distress, consisting of a continuous sensation of fullness which was worse after meals, unaccompanied

n, nausea or gas. Vomiting had occurred on a few occasions. His appetite had been poor, and the patient had lost 22 pounds (10 Kg.) in weight. For two months, sweats and chills during night and morning in a continuous feverish feeling had also been present. Constipation, which required the continuous use of cathartics and which had been present for five or six years, had recently become worse. Fatigue occurred more easily than formerly.

**Physical Examination.**—There was evidence of loss of weight; the nasal septum was deviated, and the teeth were carious. Tenderness to deep pressure in the epigastrium and muscle spasm were found. No masses could be felt, but the spleen and the liver were both palpable. Body temperature during the stay in the hospital ranged from 98 to 104 F.

**Laboratory Examination.**—The urine was normal. Examination of the blood showed 5,400,000 red cells, 10,000 white cells and a hemoglobin content of 12 Gm. per hundred cubic centimeters. A hemogram showed polymorphonuclear cells 71 per cent, lymphocytes 24 per cent and monocytes 5 per cent. Serologic reactions to a syphilis test and a Widal test and to a test for undulant

The findings were consistent with tuberculous peritonitis (fig. 1).

**Peritoneoscopy** (Jan. 24, 1944).—Multiple adhesions were present, which prevented visualization of the spleen or the liver. On the peritoneal surfaces of the adhesions and on parts of the bowel, which were unrecognizable, there were numerous tubercles, 1 to 3 mm. in diameter. Biopsy revealed tuberculosis of the peritoneum.

**CASE 3.**—The clinical diagnoses considered in this case were ulcerative colitis, diverticulitis, carcinoma of the colon and tuberculous peritonitis. The first three were excluded by careful study of the colon and small bowel, while the changes found seemed consistent with tuberculous peritonitis. Subsequent peritoneoscopy and biopsy confirmed this diagnosis.

A. Le R., a 47 year old man, was admitted to the hospital in April 1944, complaining of generalized abdominal distress of two months' duration.

**History.**—The patient, a physician in a tuberculosis sanatorium, had had pulmonary tuberculosis, which had been inactive for many years. He was well until two months before admission to the hospital, when he began

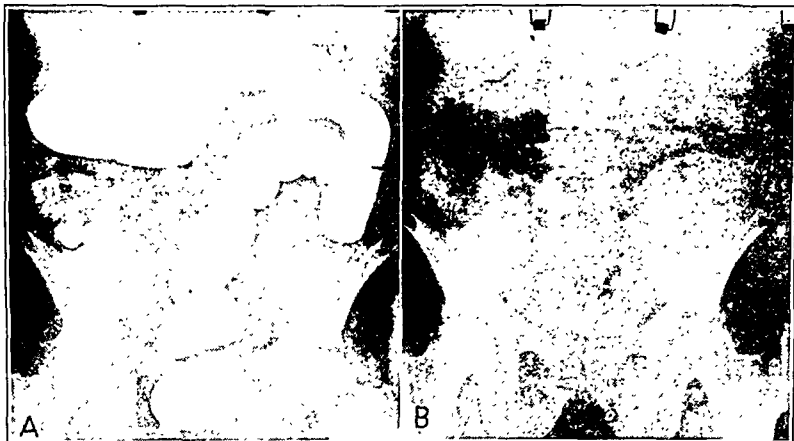


Fig. 1 (case 2).—Roentgenograms taken after a barium sulfate enema, before (A) and after (B) evacuation. There has been no change in the position of the colon after it was relieved of the weight of the barium sulfate and the patient assumed the upright position, indicating that a diffuse, adhesive process prevents motion of the colon and its mesentery.

stool were negative. The stool gave a negative reaction to the guaiac test.

**Roentgen Examination.**—A roentgenogram of the chest was essentially normal. A series of roentgenograms of the gastrointestinal tract showed no definite intrinsic disease in the esophagus, the stomach or the duodenum. A barium sulfate enema was given on Jan. 8, 1944. The colon filled readily, without evidence of obstruction. The sigmoid colon was high, and the splenic flexure was displaced medially. The cecum could not be entirely filled, but no abnormality was demonstrated. The terminal portion of the ileum appeared normal. After evacuation of the barium sulfate the mucosal pattern was normal, but there appeared to be an abnormal rigidity of the colon. There was no change in its position following evacuation. The possibility of diffuse adhesions resulting from tuberculous peritonitis was suggested. An enema of the small intestine was given Jan. 31, 1944. Hourly films showed the loops of the small bowel to be in an extremely fixed position but otherwise not remarkable.

to suffer from generalized, vague abdominal distress associated with constipation. He lost his appetite and some weight but had had no bloody or tarry stools, nausea or vomiting. For four weeks before entry to the hospital he had fever every afternoon; three weeks before his admission a localized cramplike pain in the left lower abdominal quadrant lasting an hour and recurring for a week, appeared. There had been some symptomatic improvement in the two weeks before he was admitted. A roentgenogram of the chest taken at his own hospital had shown no evidence of active tuberculosis; a barium sulfate enema had revealed some rigidity of the descending colon on the left side.

**Physical Examination.**—The patient was a well developed man, not in acute distress. His blood pressure was 130 systolic and 70 diastolic. His abdomen was distended, but there was no definite tenderness or spasm; peristalsis was not hyperactive. There was questionable shifting dullness; no masses were felt. Examination of the chest revealed generalized wheezing, which was

specially prominent in the upper part of the lungs, with no moist inspiratory rales in the apexes. In the hospital, his temperature ranged between 98.6 and 101 F.; his pulse rate varied between 90 and 120.

**Laboratory Examination.**—The urine contained albumin (2 plus) and a sediment, which consisted of red blood cells, 1 white blood cell and 3 epithelial cells per high power field and mucin, with occasional clumps. Studies of the blood showed 4,000,000 red cells, 13,500 white cells and a hemoglobin content of 1 Gm. per hundred cubic centimeters. A hemogram showed polymorphonuclear cells 75 per cent, lymphocytes 14 per cent, monocytes 10 per cent, eosinophils 1 per cent and a rare polychromatophil. There was moderate achromia, with moderate variation in the size of the red cells and normal platelets. The stool was yellow and liquid and gave a negative reaction to the guaiac test. The serologic reaction to a Hinton test was negative. The sedimentation rate of the red cells was 15, 30, 44 and 48 mm. per hour. In a sulfobromophthalein sodium test (5 mg. per kilogram) 40 per cent of the dye was excreted in forty-five minutes. A

A small intestinal enema was given on April 26, 1944. Barium sulfate flowed at a normal rate through the duodenal loop to the jejunoileal junction; mucosal relief of the jejunum was normal, and the loops were freely movable on palpation. All small bowel, however, lay above the level of the umbilicus. At the end of four minutes barium sulfate began to regurgitate into the stomach, and no progress of the small bowel was demonstrated for the next ten minutes, during which time a total of 1,200 cc. of barium sulfate solution was injected. Roentgenograms taken immediately after the enema showed beginning of the barium sulfate into the ileum, and one-half hour later it had reached the cecum. No dilated loop was apparent, and so far as could be seen the filled loops of bowel were freely movable in relation to one another. The small intestine was at all times high in position, however, and never descended below the crest of the ilium on the left side or went into the true pelvis on either side. The general configuration of the small bowel had not changed since the examinations elsewhere one month before. The position of the

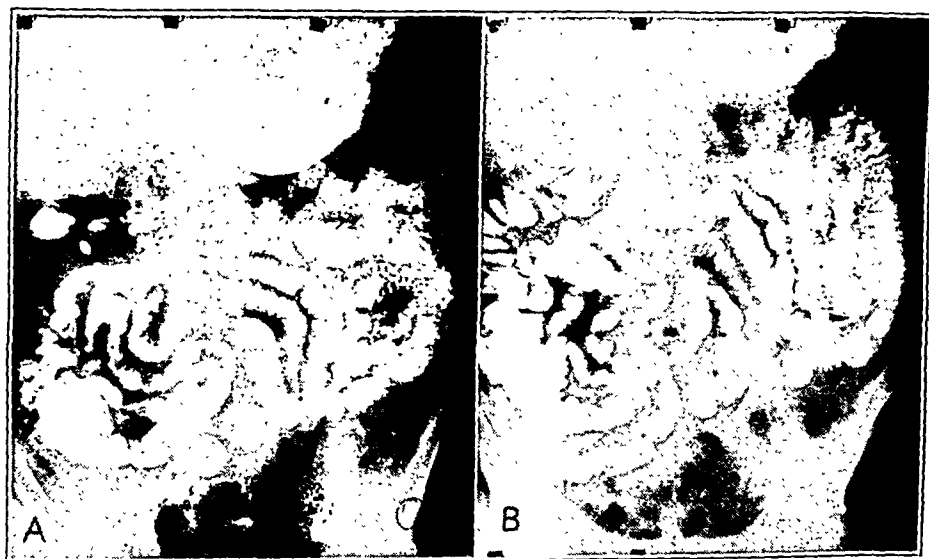


Fig. 2 (case 3).—Roentgenograms taken one-half hour (A) and one hour (B) after an enema of the small intestine. Although the individual loops of small bowel are movable, the entire small intestine is elevated and fixed in position. It can be seen that this is not caused by a pelvic tumor. The general configuration of the small bowel remains enlarged.

phal-in-cholesterol flocculation test gave a negative result.

**Roentgen Examination.**—At least two roentgenograms, which were taken at another hospital, showed the lower part of the small bowel to be fixed in position. A barium sulfate enema was given on April 26, 1944. Barium sulfate passed from the rectum to the cecum without delay. There was reflux into a normal-appearing terminal portion of the ileum. The lumen of the upper half of the rectum appeared slightly narrower than usual and the distance between the posterior abdominal wall and the sacrum greater, but there was no evidence of intrinsic defect in the upper part of the rectum or sigmoid. The midsigmoid appeared kinked in itself, and its relationship to the remainder of the sigmoid could not be changed by palpation; this suggested that it was fixed in position by extrinsic adhesions. No definite filling defect, ulceration or diverticula could be seen in the colon. Indistinct peritoneal markings indicated moderate ascites. Because the findings suggested tuberculous peritonitis, study of the small bowel was recommended.

Small bowel was abnormal and consistent with old peritonitis (fig. 2). An electrocardiogram showed no evidence of pericarditis; proctoscopy gave essentially negative results except for some spasm in the rectum.

**Peritoneoscopy** (May 2, 1944).—A small amount of fluid was demonstrable in the right lower quadrant of the abdomen, only a few drops of which could be aspirated. The peritoneal surfaces throughout were slightly reddened and presented numerous white pinpoint tubercles typical of those in tuberculous peritonitis. These were present on the round ligament of the liver, on the small bowel and on the peritoneal surface of the abdominal wall. The liver appeared normal. Histologic studies revealed no diagnostic abnormalities of the liver and tuberculosis of the peritoneum.

**CASE 4.**—This patient was from another hospital where an exploratory laparotomy and biopsy had been done. Owing to the unavoidable lag in the transmission of records the patient was fully studied before the history and slides were received. The diagnosis was made on the basis of the changes in the large bowel and was substantiated later by the surgeon's report.

and the microscopic sections, which were reviewed by the pathologist at the Massachusetts General Hospital.

*History.*—P. M., a 16 year old single Turkish girl, was admitted to the hospital in April 1944, complaining of chills and fever of one year's duration. She had had no known contact with tuberculosis. One year before admission to the hospital she had noted fatigue and a run-down feeling, which one week later were followed by daily nausea and vomiting, chills and fever. The nausea and the vomiting subsided at the end of a week with treatment at the hospital, but chills, fever, anorexia and fatigue continued, in spite of rest in bed. After an exploratory laparotomy she spent six months in a sanatorium, without improvement.

*Physical Examination.*—The patient was an underdeveloped or undernourished, tired-looking girl who appeared chronically ill. Her pulse rate was 110 and her blood pressure was 90 systolic and 70 diastolic. There was tenderness over the right side of the epigastrium in the region of the operative scar. Her temperature on admission to the hospital was 101 F., ranging throughout hospitalization between 99 and

pyelogram showed no abnormalities. A roentgenogram of the chest showed calcification in the base of the upper lobe of the right lung and a calcified gland in the mediastinum. There was no definite evidence of active disease within the pulmonary fields. A roentgenogram of the abdomen indicated that the bones of the pelvis were somewhat atypical.

A barium sulfate enema was given on April 20, 1944. Barium sulfate flowed readily to the cecum, and the entire colon filled well. The ileocecal valve opened, and a long loop of ileum in the terminal portion filled and appeared normal. The film taken after evacuation showed good emptying and a normal colon. There were, however, numerous loops of nondilated small bowel on the right side of the abdomen.

A roentgenographic series of the gastrointestinal tract on April 26, 1944 showed that the esophagus was normal, that the stomach contained considerable secretion, which obscured the details of the gastric mucosa, and that there was a small residue of the motor test meal. The pylorus opened after a slight delay; the duodenal cap was deformed. On the greater curvature

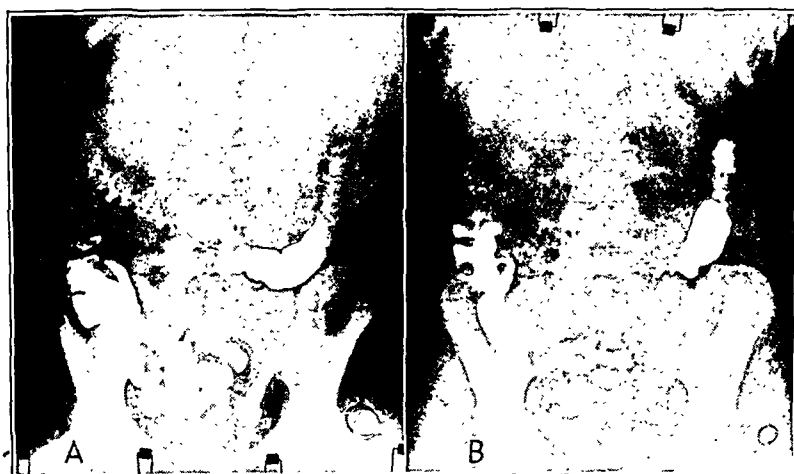


Fig. 3 (case 4).—Two roentgenograms of the same patient taken one week apart, each after evacuation of a barium sulfate enema. Comparison of A and B shows that there has been only a slight change in the position of the colon and the terminal portion of the ileum. The configuration of the terminal portion is abnormal, suggesting a matting together of the loops.

104.5 F. (practically sustained fever with a rare normal temperature). Her pulse rate was from 80 to 130, averaging 100; her respiratory rate was from 20 to 35.

*Laboratory Examination.*—The urine was normal. Examination of the blood revealed 4,200,000 red cells, 21,200 white cells and a hemoglobin content of 12 Gm. per hundred cubic centimeters. A hemogram showed polymorphonuclear cells 79 per cent, lymphocytes 14 per cent, monocytes 3 per cent, a few toxic polymorphonuclear cells, no malaria organisms, myelocytes, 4 per cent and a few target cells. A smear was normal. The sputum was thick and mucoid gray and contained no tubercle bacilli. Both the sputum and the stool gave negative reactions to a guaiac test. The gastric juice contained no tubercle bacilli and no free acid; there was 1 unit of acid after administration of histamine. A nasal smear failed to reveal tubercle bacilli. The reaction to tuberculin in a 1:10,000 dilution was strongly positive.

*Roentgen Examination* (April 17, 1944).—Roentgenograms showed enlargement of the spleen, with the liver within the upper limits of normal. An intravenous

was a crater, approximately 2.5 cm. distal to the pylorus and slightly toward the anterior wall. The crater measured 5 mm. The remainder of the duodenal loop appeared normal. The residue of the motor meal was in the terminal portion of the ileum and the proximal part of the colon (fig. 3).

Another barium sulfate enema was given April 28, 1944. The results were normal except for slight irritability in the cecum and the ascending colon, which were filled and appeared normal. After the results of the two examinations were compared the conclusion was that it was unusual for the colon and the demonstrated portion of the lower part of the small intestine to remain in the same position. This suggested a lack of flexibility and changes similar to those in dry tuberculous peritonitis.

Microscopic sections from another hospital were received and reviewed on April 29, 1944. There was histologic evidence of tuberculosis.

*CASE 5.*—This patient was seen some years before the present study was begun. The case is included because the roentgenologic changes were extensive,

Although their full diagnostic significance was not realized at the time. Study of the small bowel was repeated in 1944 by passing the barium mixture through Miller-Abbott tube, and the matting together of the small bowel persisted. The diagnosis was made by exploratory laparotomy and biopsy; it might have been made on the basis of the roentgenographic appearance of the small bowel.

A. K., a 38 year old married woman, was admitted to the hospital in March 1940, because of abdominal pain of seven months' duration.

*History.*—She had been in the hospital for one week in October 1936, at which time she was discharged with the diagnosis of "abdominal pain of undetermined origin, calcified abdominal glands and question of old tuberculous peritonitis." She was fairly well between 1936 and 1940 but continued to have recurrent, moderate attacks of pain in the right lower quadrant of the abdomen, at times radiating down the anterior surface of the right leg. In August 1939, a colicky, midhypogastric pain appeared; in October she was confined to bed for a month because of abdominal pain,

and 80 diastolic; her temperature was normal and pulse rate 80 to 100.

*Laboratory Examination.*—The urine was normal. Studies on the blood revealed 4,040,000 red blood cells, 9,400 white blood cells, a hemoglobin content of 10 per cent, polymorphonuclear cells 60 per cent, lymphocytes 30 per cent, monocytes 9 per cent and eosinophils 1 per cent. A smear was normal. The stool was light gray and liquid and gave a negative reaction to guaiac test. The Hinton test gave a negative result. The reaction to the van den Bergh test was normal. The blood protein content was 6.6 per cent and the protein nitrogen 18 mg. per hundred cubic centimeters.

*Roentgen Examination.*—A plain roentgenogram of the abdomen revealed multiple areas of calcification in the lower part of the abdomen, which were probably calcified glands. There were several slightly dilated loops of small intestine in the left upper abdominal quadrant and a small amount of gas in the large intestine. A barium sulfate enema was given March 1940. The enema indicated probable calcified glands; extrinsic pressure in the region of the sigmoid. See

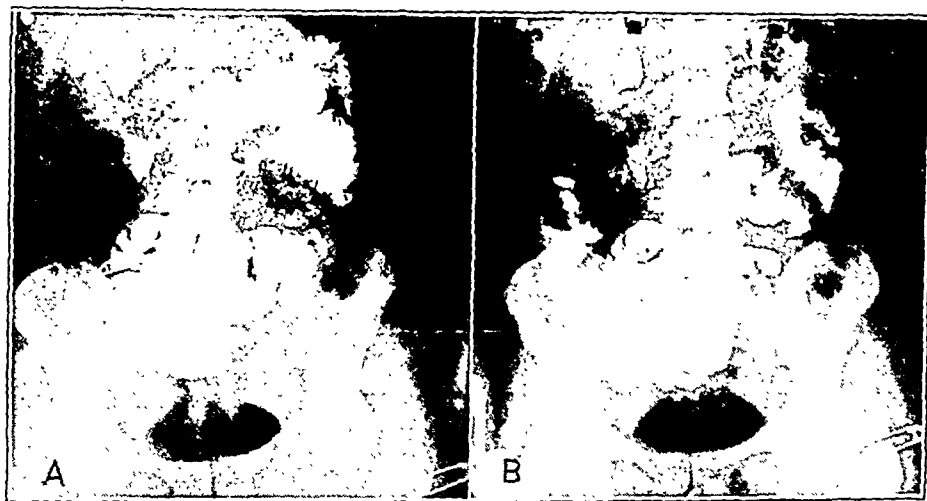


Fig. 4 (case 5).—Roentgenograms of the small bowel taken hourly. A, four hours after administration of barium sulfate. B, five hours after administration of barium sulfate. The small intestine is drawn into the abdomen and matted together, owing to the diffuse adhesive process. Slight widening and irregularity of the spaces between the loops of intestine can be seen.

associated with chills and intermittent sweats. During the last two weeks of this illness she became jaundiced and the stools were clay colored; the pain shifted in location, occasionally radiating to the angle of the right scapula. One week before entry to the hospital the stools were again light colored, but she was not undressed. There had been no vomiting, diarrhea or watery stools, although when she was constipated the stools had at times been flecked with blood. There had been no loss of weight.

*Physical Examination.*—The patient was fairly well developed and nourished and not in acute distress. Her tongue was pale, as were her hands, which had a peculiar cyanotic appearance in the fingers. The abdomen was slightly distended; there was hyperreflexia; palpation was difficult, owing to resistance of the abdomen. The liver and the spleen were not felt; there was slight tenderness in the right upper quadrant of the abdomen. Pelvic examination showed a poorly defined mass in the left lower abdominal quadrant, the size of a hen's egg, apparently connected with the fundus and occupying the position of the left ovary. The blood pressure was 120 systolic

and 80 diastolic; her temperature was normal and pulse rate 80 to 100. roentgenograms of the small intestine on March 11, 1940 showed no delay in the passage of barium. The jejunal loops showed some dilatation, which changed in degree during the examination. The ileum was not dilated. Its loops stayed together in a rather peculiar constant arrangement, as if they were in some kind of sac. There was definite abnormality in the small intestine, which was considered to be due to an underlying peritoneal lesion. A second examination confirmed the partial obstruction, but it was still a question whether adhesions had produced the abnormalities (fig. 4).

*Exploratory Laparotomy* (March 27, 1940).—No free peritoneal cavity could be demonstrated. The abdomen looked as if glue had been poured into it and had stiffened it to a tough fibrous consistency, which bound adjacent coils of intestine together. These adhesions formed septums, or compartments. A piece of one of them was isolated for biopsy. There was histologic evidence of tuberculosis.

*CASE 6.*—This case indicates that changes in the peritoneal cavity will persist for some time after apparent subsidence of disease.

A. S., a 35 year old Negro woman, was admitted to the hospital in May 1944, because of syphilis of the central nervous system.

*History.*—Three years before admission to the Massachusetts General Hospital she was treated in another hospital for chronic tuberculous peritonitis, proved by aspiration and guinea pig inoculation. On admission to the Massachusetts General Hospital she complained of vague pain in the abdomen and occasional nausea but no vomiting. This patient was studied because of interest in determining how long roentgen changes attributable to tuberculous peritonitis persist, although the patient becomes relatively asymptomatic.

The results of laboratory tests, the temperature, the pulse and the respiratory rate were normal.

*Roentgen Examination.*—A roentgenogram of the chest was essentially normal. A small intestinal enema was given May 23, 1944. Barium sulfate passed through the small intestine rapidly, reaching the cecum in five or six minutes. The length of the small intestine was less than normal, and there was some fixation of the loops. The space between the individual loops, however, was widened. At the end of three hours the greater part of the barium sulfate had passed into the colon. There was some abnormal segmentation of the small bowel. The findings suggested adhesive peritonitis, probably tuberculous in origin. A barium sulfate enema showed a normal large bowel.

#### SUMMARY

Six cases of tuberculous peritonitis are presented in 3 of which the preoperative diagnosis was suggested by the roentgenographic appearance of the large and the small bowel.

Tuberculous peritonitis results in a diffuse adhesive process involving the peritoneal surfaces. This gives rise to certain distinctive features, which may be seen on the plain roentgenogram and on roentgenograms of the large and small intestines taken after barium sulfate enemas. These diagnostic points are:

1. A low grade ileus with a varying amount of intra-abdominal fluid will be seen on the plain roentgenogram.

2. The barium sulfate enema will show the large bowel to be in a fixed position. Occasionally adhesions can be demonstrated.

3. The enema of the small intestine will disclose rapid passage of the barium sulfate as a rule. The loops of the intestine are bound together, and the bowel is shorter than normal. The intervening spaces between the barium-filled loops tend to be slightly widened and irregular. Abnormal segmentation may be seen.

# EFFECT OF MASSIVE EXPERIMENTAL HEMORRHAGE ON HEPATIC FUNCTION IN DOGS

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Little can be found in the literature at the present time, from either the experimental or the clinical standpoint, to indicate what effect massive hemorrhage followed by shock might have on hepatic function. Since the liver is important for the synthesis of certain blood proteins, including fibrinogen, and since severe hemorrhage can considerably deplete these proteins, impaired hepatic function produced by hemorrhage might result in inadequate restoration. It is possible that other functions of the liver also might be decreased as a result of hepatic cellular damage due to hemorrhage. Patients who die of severe postoperative shock caused by hemorrhage present clinical manifestations similar to those observed in so-called "liver death," which has been described in detail by Boyce and McFetridge<sup>1</sup> and others. However, it is well established that most of the patients with manifestations of "liver death" have had definite impairment of hepatic function due to previous hepatic infection or damage and perhaps have had a preoperative hepatic function which was at or below the critical level. It has not been established as yet that severe hemorrhage causes enough hepatic damage to be of any significance.

The experimental work to be presented was performed in an effort to determine whether or not massive hemorrhage could produce enough damage to the liver to give rise to hepatic insufficiency. The work of Blalock<sup>2</sup> and of others has sufficiently proved that shock per se and shock due to hemorrhage are two separate and distinct clinical entities, although similar in many respects. The former is identified by hemoconcentration and definite pathologic changes in the organs which are observed at necropsy and is characterized by diffuse edema and focal necroses in the liver, kidneys and other organs. The typical picture seen at necropsy after death due

to hemorrhage, in contradistinction, consists of hemodilution and normal organs except for the pallor and shrunken appearance.

DeLor and Reinhart,<sup>3</sup> in their analysis of tests of hepatic function in 381 cases, found that the sulfobromophthalein (bromsulphalein) test, the blood prothrombin test and the hippuric acid test gave roughly parallel results as hepatic function was diminished. The galactose tolerance test was the least reliable. The sulfobromophthalein test was the most sensitive for the identification of early hepatic damage. The mortality rate mounted rapidly for persons with 50 per cent or more diminution of hepatic function, as estimated by these tests. DeLor and Reinhart conclude that if results of two or more of the tests indicate diminished hepatic function the mortality and the morbidity rate are definitely greater and that as yet no single test of hepatic function furnishes as reliable a prognosis as that which may be derived from two or more tests.

Rhoads and Warren<sup>4</sup> studied the prothrombin content of the plasma in persons with hepatic injury and also in completely hepatectomized dogs and stated that the liver is probably the sole source of synthesis of prothrombin. Smith and co-workers,<sup>5</sup> in recent work in their laboratory, showed that the liver is important in the manufacture of prothrombin. Ordinary tests for determining bleeding and clotting time reveal an abnormality only when prothrombin deficiency is extreme. They give normal results even when the plasma prothrombin value is approaching the danger level. Smith and associates have found by their bedside technic that a tendency to bleeding commonly occurs when the test gives values of 40 per cent or less. Values of 40 to 70 per cent are definitely in the danger zone. They also noted that for laboratory workers the normal variations in the prothrombin time are rarely more than 15 per cent of normal.

From the Department of Surgery, University of Illinois College of Medicine, and the Research and Educational Hospital.

1. Boyce, F. F., and McFetridge, E. M.: So-Called "Liver Death": Clinical and Experimental Study, *Arch. Surg.* **31**:105 (July) 1935.

2. Blalock, A.: *S. Clin. North America* **21**:166-1683 (Dec.) 1941.

3. DeLor, J., and Reinhart, H. L.: *Am. J. Clin. Path.* **10**:617 (Sept.) 1940.

4. Warren, R., and Rhoads, J. E.: *Am. J. M. Sc.* **198**:193 (Aug.) 1939.

5. Smith, H. P.; Ziffren, S. E.; Owen, C. A., and Hoffman, G. R.: *Am. J. Clin. Path., Tech. Supp.* **4**:13 (Jan.) 1940.

Price, Hanlon, Longmire and Metcalf,<sup>6</sup> in their experiments on the effects of acute hemorrhage in healthy dogs reported no specific data regarding the effects on hepatic function in the animals in their series. The amount of blood which they removed per animal averaged 35.8 cc. per kilogram of body weight. The amount of blood removed from animals in our series to produce massive experimental hemorrhage was only 30 cc. per kilogram. However, the bleeding time for our experiments, being only thirty minutes, was much shorter than that used by Price and co-workers.

Moon and associates<sup>7</sup> suggested that for the sake of accuracy the expression "shock and hemorrhage" should be substituted for the term "hemorrhagic shock." They urged investigators not to use hemorrhage as a means of producing shock experimentally. If the results so obtained are interpreted as applying to shock, erroneous conclusions may be drawn. Harkins<sup>8</sup> stated that his work and that of Blalock and of others have led to a conclusion contrary to that of Moon, namely, that if the hemorrhage is allowed to continue long enough the restitution of even more blood than was lost will not restore the animal or the patient.

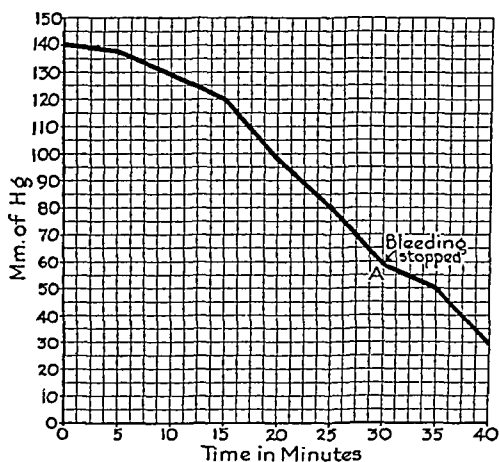
#### EXPERIMENTAL TECHNIC

In an attempt to simulate as closely as possible conditions of hemorrhage as they would occur in the operating room, dogs, under anesthesia induced with intravenously administered pentobarbital sodium, were bled from the jugular vein, predetermined amounts of blood being taken every five minutes for from thirty to thirty-five minutes. Previous experimental work has shown that if blood in the amount of 0.5 per cent of body weight is withdrawn every five minutes for thirty minutes the blood pressure drops below the critical level and death invariably ensues within ten minutes unless supportive therapy is given immediately on cessation of the bleeding.

The accompanying graph represents the mean blood pressure readings for many experimental animals. If, for example, blood equal to 0.5 per cent of the weight of a dog weighing 15 Kg., or 75 cc., was withdrawn every five minutes for thirty minutes, 525 cc. of blood would be removed. This corresponds to approximately 3 per cent of the body weight. Bleeding was terminated at this point, designated by A on the graph. The mean blood pressure, indicated by A, was 58 mm. of mercury. The blood pressure readings were checked both by a cannula in the femoral artery and by a cuff on the leg. However, the criterion used to determine the end point of the bleeding was not the blood pressure but the

calculated total amount of blood. Obviously with this method several animals died before our bleeding technic became sufficiently accurate to bleed the animals to the minimum level compatible with life. A total of 12 animals were bled in this manner. Four animals had to be given transfusions of from 2 to 3 ounces (60 to 90 cc.) of their own blood in order to keep them alive. One animal died within the first twelve hours, apparently from hemorrhage.

The 11 animals that survived were subjected to tests of hepatic function at varying intervals postoperatively for ten days. The tests used were the sulfobromophthalein sodium (bromsulphalein) test, as described by Rosenthal and White,<sup>9</sup> the galactose tolerance test, introduced by Bauer<sup>10</sup> in 1906, the prothrombin time test, with the bedside technic of Smith and associates,<sup>5</sup> and the serum phosphatase test.<sup>11</sup> The hippuric acid excretion test, as clinically employed by Delprat and Whipple,<sup>12</sup> did not give accurate results in normal dogs with sufficient consistency to warrant its use in the experimental data. Also, the important cephalin-cholesterol flocculation test, described by Hanger,<sup>13</sup>



Mean blood pressure readings for experimental animals.

could not be used for the reason that the serum of normal dogs is flocculated by this technic. Control tests were performed on normal dogs.

#### RESULTS

The normal values used for the various tests may be listed as follows: Values of 1 to 4 mg. of serum phosphatase per hundred cubic centimeters of serum were considered normal. The mean prothrombin time calculated for normal animals averaged eleven seconds. Any excretion of more than 1.5 Gm.

9. Rosenthal, S. M., and White, E. C.: Clinical Application of Bromsulphalein Test for Hepatic Function, *J. A. M. A.* **84**:1112 (April 11) 1925.

10. Bauer, A.: *Wien. med. Wchnschr.* **56**:20, 1906.

11. Gutman, A. B.; Olson, K. B.; Gutman, E. B., and Flood, C. A.: *J. Clin. Investigation* **19**:129 (Jan.) 1940.

12. Delprat, G. D., and Whipple, G. H.: *J. Biol. Chem.* **49**:229 (Nov.) 1921.

13. Hanger, F. M.: *J. Clin. Investigation* **18**:261 (May) 1939.

6. Price, P. B.; Hanlon, C. R.; Longmire, W. P., and Metcalf, W.: *Bull. Johns Hopkins Hosp.* **69**:327 (Oct.) 1941.

7. Moon, V. H.; Morgan, D. R.; Lieber, M. M., and McGrew, D.: Similarities and Distinctions Between Shock and Effects of Hemorrhage, *J. A. M. A.* **117**:2024 (Dec. 13) 1941.

8. Harkins, H. N.: *Surgery* **9**:231 (Feb.) 1941.



of galactose was regarded as indicative of impaired hepatic function. The control animals which were submitted to the galactose tolerance test never excreted more than 1 Gm. of galactose. Twenty grams, or half of the standard clinical dose, was used. All the animals in the series approximated 15 Kg. in weight; so the dose was not varied. Retention of 35 per cent or less of sulfobromophthalein sodium in five minutes and of a trace or less in thirty minutes was regarded as normal.

The result of the prothrombin time test was 100 per cent of normal for 4 animals, 92 per cent of normal for 2, 84 per cent of normal for 4 and 73 per cent of normal for 1 animal, the last result indicating perhaps slight impairment of hepatic function. The results for the control animals were 100 per cent of normal except for 1, which was 92 per cent of normal.

The serum phosphatase values were within normal limits for all animals.

hemorrhage, was to estimate the effect of mass experimental hemorrhage on the functions of liver.

The sulfobromophthalein sodium test gave entirely normal results for 8 of 11 dogs, and rest for the other 3 animals were just barely above the upper limits of normal.

The serum phosphatase readings were within the range of normal variation. Drill, Anneg and Ivy,<sup>14</sup> in recent experimental work, concluded that the serum phosphatase level is of definite value in determining impairment of hepatic function.

The prothrombin time was normal or within the variations of normal for 6 of 11 animals. However, for 1 animal a result of 73 per cent of normal was still 33 per cent above the prothrombin time at which a tendency to bleed is supposed to occur.

The galactose tolerance test was the only one that consistently showed results indicative

Results of Tests of Hepatic Function

Number of dog.....	1	2	3	4	5	6	7	8	9	10	11
Retention of sulfobromophthalein sodium											
5 minutes.....	45%	30%	30%	25%	50%	40%	30%	5%	20%	35%	Trace
30 minutes.....	5%	Trace	0	0	15%	10%	5%	0	0	Trace	0
Prothrombin time, per cent of normal.....	92	84	100	84	84	73	100	92	100	100	84
Galactose tolerance, Gm.....	0.937	1.5	1.66	3.69	2.59	0.651	8.73	4.04	4.59	3.19	4.94
Serum phosphatase, mg./100 cc.	1.12	1.80	1.19	1.91	1.66	2.05	1.27	1.25	1.69	1.44	2.11

The sulfobromophthalein test gave results within normal limits for all but 3 animals, which had a retention of the dye slightly above the normal limit.

The galactose tolerance test revealed an excretion above normal in 8 of the 11 animals, indicating hepatic impairment in those animals. Those animals were not checked to see if the galactose tolerance returned to normal later.

COMMENT

Shock as mentioned in this paper refers only to the syndrome of shock produced by hemorrhage and accompanied by peripheral circulatory failure with vasoconstriction, hemodilution and a rapid, easily compressible pulse. Blalock stated: "The blood loss that will produce death in dogs is approximately five per cent of the body weight." The amount of blood withdrawn from our animals was slightly less; however, we endeavored to produce only sublethal hemorrhage, and the bleeding time was limited to thirty minutes.

The purpose of these experiments, avoiding entirely the controversial subject of shock versus

hepatic damage, the excretion of galactose being above normal for 8 of 11 animals. Any excretion of galactose above 1.5 Gm. was considered abnormal or denoting a damaged hepatic parenchyma. Of the 8 animals with excretions above normal, 6 excreted 3.69 Gm. or more. Seven animals excreted 2.59 Gm. or more, and 1 animal excreted 8.73 Gm., or over a third of the initial dose of 20 Gm.

In summarizing the experimental work of the various workers for the past few years, we note a general agreement that the galactose tolerance test is one of the most valuable of the various tests of hepatic function, in contradistinction to the opinion of DeLor and Reinhart, who conclude that the galactose tolerance test was the least reliable one used in their series. However, most workers are in agreement that its greatest value lies not in its ability to detect the amount of hepatic damage but in its aptitude to differentiate in a large percentage of cases, icterus due to mechanical block from that of the toxic or infectious type.

14. Drill, V. A.; Annegers, J. H., and Ivy, A. C. Proc. Soc. Exper. Biol. & Med. 54:242 (Nov.) 1943

In an effort to produce even a finer dividing line between sublethal hemorrhage produced on the initial attempt and death small amounts of blood were removed daily, postoperatively, in an endeavor to reach a level which would still be compatible with life. However, this additional bleeding was not successful because we had no means by which to gage how the amount of blood removed would be tolerated. The removal of only small amounts, of from 10 to 30 cc., invariably resulted in death almost immediately. This agrees with the work of Price and co-workers, who stated that in the late stages of posthemorrhagic shock dogs become extremely sensitive to loss of blood, so that even the loss of only a few cubic centimeters may precipitate collapse of the circulation. Obviously, if enough animals were bled sooner or later an occasional dog would be bound to survive long enough to have tests of hepatic function performed at a time when the parenchymatous organs had been affected by the general anoxia due to massive experimental hemorrhage.

Although the irreversible changes due to anoxia in the parenchymatous organs occur after hemorrhage, they appear only after anoxia has been present for a sufficient length of time. Seven of the 11 animals in this series which received no supportive therapy still appeared to be in hemorrhagic shock the next day, as evidence by their listlessness and unresponsiveness. This continued evidence of shock with its accompanying anoxia would tend to indicate an anoxia of sufficient duration to produce damage to the parenchymatous organs. However, the fact that in a few days the dogs were up and about and appeared fairly normal on clinical observation seems to emphasize the enormous reserve of the dog's hepatic function, besides the remarkable capability of the animal to recover after hemorrhage. Obviously, from the multiplicity of functions possessed by the liver, no single test will detect impairment of all the functions unless the damage

is severe. However, it is generally agreed that if one or two tests give positive results at least a certain amount of hepatic insufficiency exists. In other words, the tests are so insensitive that a positive result must be considered distinctly significant. True, certain tests yield false positive results. The cephalin-cholesterol flocculation test is an example of this, but it was not used in these experiments. The wide margin of safety possessed by the liver, only 30 to 40 per cent being necessary to maintain life (with undoubtedly less in animals), offers a possible explanation of only mild impairment of function produced by hemorrhage in our experiments. Routine determinations of sulfobromophthalein and prothrombin levels for patients after massive operative hemorrhage might aid in solving this question, for patients in posthemorrhagic shock clinically present a picture similar to that described as associated with "liver death."

#### SUMMARY

Massive acute experimental hemorrhage was produced in 12 dogs.

The sulfobromophthalein sodium, galactose tolerance, serum phosphatase and prothrombin time tests of hepatic function were performed on these animals at varying intervals after the bleeding. Control tests had previously been made on normal animals.

The galactose tolerance test revealed marked impairment of the liver's ability to assimilate galactose, as 8 of 11 animals excreted amounts far in excess of those of the control animals, which were considered normal.

The prothrombin time was prolonged definitely for 4 of the 11 animals.

Results of sulfobromophthalein and the serum phosphatase test were normal.

We believe that definite although slight impairment of hepatic function as evidenced by the results of the tests used in our experiments was produced by massive acute hemorrhage.

# ASEPTIC NECROSIS OF THE HEAD OF THE FEMUR FOLLOWING TRAUMATIC DISLOCATION OF THE HIP

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The purpose of this report is twofold: first, to call attention to the possibility of traumatic dislocation of the hip occurring without rupture of the ligamentum teres; second, to record a typical case of aseptic necrosis and deformity of the head of the femur with its ligamentum teres intact and thoroughly vascularized, the pathologic condition having arisen from a traumatic interruption of the blood supply of the femoral head coming through the capsule of the hip joint.

It had been my impression<sup>1</sup> that aseptic necrosis of the femoral head following a traumatic dislocation of the hip was the result of two factors: (1) rupture of the ligamentum teres during the dislocation, with consequent deprivation of its blood supply to part of the femoral head, especially to the summit of the head, and (2) too early weight bearing, with collapse of the osseous lamellas before adequate regeneration of bone. My belief was seemingly confirmed by the conclusions of Banks and Phemister.<sup>2</sup> The clinicopathologic picture seemed dependent on a rupture of the capsule of the hip joint and more particularly on a rupture of the ligamentum teres, a tear of which was apparently inevitable in a traumatic dorsal dislocation. Early roentgen examination showed involvement mainly of the top, or proximal, portion of the femoral head, explicable on the basis that the blood supply was cut off from the ligamentum teres and an anemic infarct was formed. Later changes, or irregularities of the femoral head, islands of necrotic bone and marginal osteophytes were the result of aseptic necrosis of the bone and nature's efforts at repair.

Read before the Orthopaedic Section of the New York Academy of Medicine on April 21, 1944.

1. Kleinberg, S.: Aseptic Necrosis of the Femoral Head Following Traumatic Dislocation, *Arch. Surg.* **39**: 637 (Oct.) 1939.

2. Banks, S. W.: Aseptic Necrosis of Femoral Head Following Traumatic Dislocation of the Hip, *J. Bone & Joint Surg.* **23**:753 (Oct.) 1941. Phemister, D. B.: Fractures of Neck of Femur, Dislocation of Hip, and Obscure Vascular Disturbances Producing Aseptic Necrosis of Head of Femur, *Surg., Gynec. & Obst.* **59**: 415 (Sept.) 1934.

Aseptic necrosis encountered in other conditions, such as Legg-Perthes disease, has assumed to be a direct result of interference of the blood supply coming to the femoral head through the ligamentum teres. This assumption was based mainly on experimental work in which section of this ligament led to gross histologic changes in the femoral head which were identical with those observed in Legg-Perthes disease. Several years ago, in studying the ligamentum teres removed at operative cases of Legg-Perthes disease and case of slipped femoral epiphysis, I<sup>3</sup> was surprised to find that in at least several cases of Legg-Perthes disease the ligamentum teres had patent and adequate arteries and veins which showed no disease of their walls and were apparently normal. It then became apparent that aseptic necrosis of the femoral head was not always the sequel to an interruption of the blood supply from the ligamentum teres.

The case to be reported is another interesting instance of aseptic necrosis of the femoral head following a traumatic dislocation in which exposure of the hip some time after the injury showed a normal ligamentum teres with patent blood vessels and no scars to indicate a previous injury. The pathologic condition must have resulted from damage to the capsular vessels. This experience refutes my own impression and the opinion of others<sup>2</sup> that the ligamentum teres is ruptured in every case of traumatic dorsal dislocation of the hip.

It is now common knowledge from numerous angiologic studies that the femoral head has three sources of blood supply, namely, the ligamentum teres, the capsular vessels and the vessels in the femoral neck. The amount of blood from each of these sources varies at different ages and in

3. Zemansky, A. P., Jr., and Lippman, R. K.: The Importance of the Vessels in the Round Ligament to the Head of the Femur During the Period of Growth, and Their Possible Relationship to Perthes' Disease, *Surg., Gynec. & Obst.* **48**:461 (April) 1929.

4. Kleinberg, S., and Friedman, E.: Observations on the Vascularity of the Ligamentum Teres, *Bull. Hosp. Joint Dis.* **1**:72 (July) 1940.

different persons. Generally speaking the supply through the ligamentum teres is less than through the other avenues. One is reminded of the work of Wolcott,<sup>5</sup> who in recent years and with wider experience concluded that the blood supply entering the ligamentum teres was of minor

importance in contrast to the rich supply from the capsule and the periosteum.

## REPORT OF A CASE

A. H., a man 20 years of age, was admitted to my service on Dec. 9, 1941, because of pain and stiffness

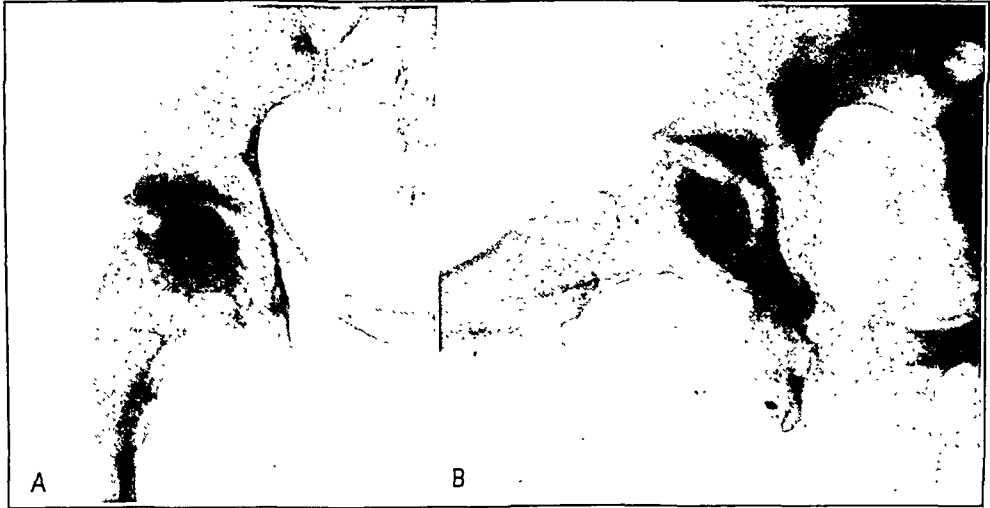


Fig. 1.—*A*, anteroposterior roentgenogram of the right hip, showing marked enlargement and irregularity of the femoral head, considerable reduction in the vertical diameter of the head and numerous vacuolated, or porotic, areas and patches of sclerosis. There is some formation of new bone at both the superior and the inferior border of the head. The epiphyseal line has disappeared. *B*, lateral roentgenogram of the hip, showing flattening and irregularity of the articular surface of the head, several clearly visualized vacuolated areas and extensive sclerosis. There is periosteal formation of new bone on the inferior border.

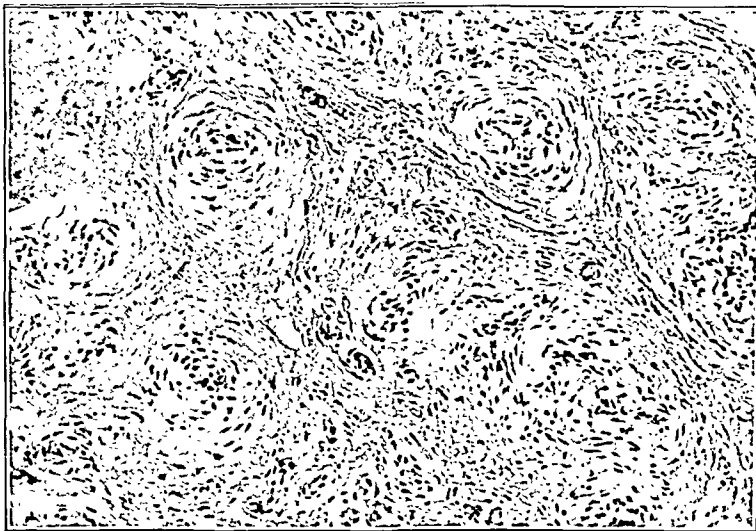


Fig. 2.—Section of the ligamentum teres ( $\times 100$ ). There are numerous patent blood vessels and no evidence of a tear or reparation in the connective tissue to indicate an injury. The walls of the arteries are thickened but not to an abnormal degree.

5. Wolcott, W. E.: Circulation of the Head and Neck of the Femur: Its Relation to Nonunion in Fractures of the Femoral Neck, *J. A. M. A.* **100**:27 (Jan. 7) 1933.

in the right hip and a limp. Four years previously he was injured in a ball game, sustaining a dislocation of the right hip. He was taken to a hospital, where the dislocation was promptly reduced. A splint was not applied, and after rest in bed for two weeks he

was allowed to walk. One year later he began to have occasional slight pain in the hip. The pain gradually became more frequent and more severe. During the year before I saw him his physical activity had been hampered and increasingly restricted, so that just prior to his admission to my service he was able to walk only about four blocks without great discomfort. Physical examination showed that the patient walked with a limp on the right side. The motions in the hip were restricted. Extension was possible to 180 degrees, but flexion was checked at 70 degrees. Inward rotation

the head were numerous porotic, or vacuolated, areas (seen especially in figure 1B) and spotty sclerotic patches. The upper surface of the head was depressed, and the articular surface was irregular. There was a periosteal thickening on the inferior border of the neck. The lateral view showed great distortion of the head with partial absorption of the outer part of the head and numerous areas of rarefaction and sclerosis. The epiphyseal line had disappeared. The roentgenologist's diagnosis was aseptic necrosis of the femoral head, with which I concurred.

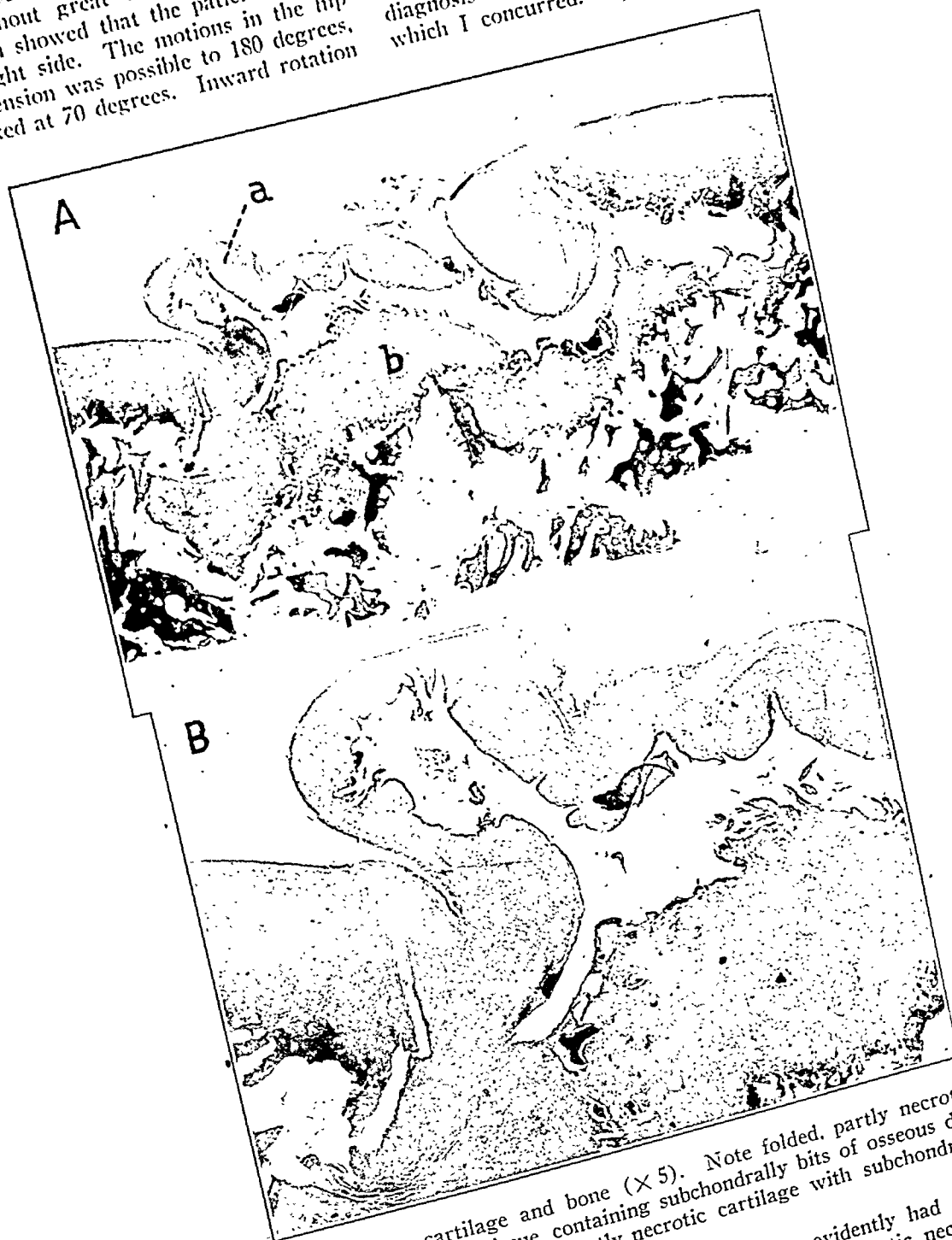


Fig. 3.—A, section of articular cartilage and bone ( $\times 5$ ). Note folded, partly necrotic articular cartilage at a. At b there is hyalinized connective tissue containing subchondrally bits of osseous detritus. B, same section as in figure 3A ( $\times 20$ ). This shows the folded partly necrotic cartilage with subchondral bits of dead bone.

was limited to a few degrees only and outward rotation to about 30 degrees. Adduction was free, but abduction was checked at 5 degrees. There was no shortening of the right limb, but there was an atrophy of the thigh of  $1\frac{3}{4}$  inches (4.5 cm.) and of the leg of about  $\frac{1}{2}$  inch (1.3 cm.).

Roentgenograms showed an extensive change in the shape and structure of the femoral head (fig. 1). The head was enlarged and irregular; its outer surface extended somewhat beyond the acetabulum. Within

The patient evidently had osteoarthritis of the right hip secondary to aseptic necrosis of the femoral head which followed a traumatic dislocation of the hip. A arthroplasty gave me an opportunity to inspect the whole hip joint. The capsule of the hip joint appeared normal in thickness and color and, grossly at least, exhibited no recognizable signs of previous infection. The ligamentum teres was attached to the top of the femoral head at what seemed logically the fovea.

Sections of the capsule, the ligamentum teres, the articular cartilage and the femoral head were removed for microscopic study. Pathologic examination showed that the synovial lining of the capsule was thickened. The articular cartilage was indented in many areas. In all of the osteochondral fragments removed from the head there were subchondral cystic fibrous nodules,

cartilage, which was articular cartilage that had folded after the collapse of the subchondral bone, was necrotic, and beneath it there was a layer of fibrous tissue and fibrocartilage.

Thus there were evidences of typical, advanced and extensive aseptic necrosis in the femoral head. The

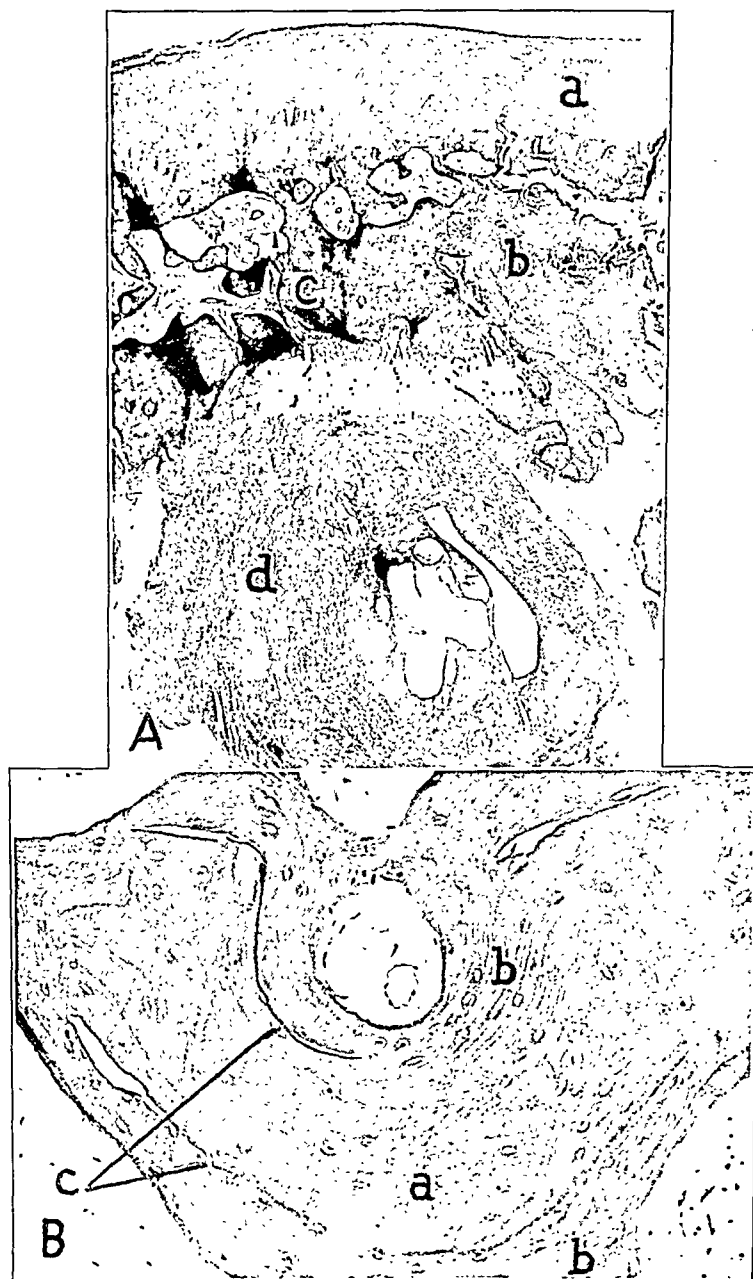


Fig. 4.—*A*, section of articular cartilage and subchondral tissue ( $\times 25$ ): *a*, articular cartilage; *b*, focus of lined connective tissue containing islands of necrotic bone; *c*, modified subchondral bone, some of which has undergone aseptic necrosis; *d*, large focus of cystic fibrous tissue. *B*, subchondral bone ( $\times 150$ ): *a*, dead bone; *b*, living bone; *c*, cement lines.

as large as 1 cm. in diameter; these corresponded to the rarefied areas in the roentgenograms. The ligamentum teres was well vascularized. Tissues from the femoral head showed a good deal of residual aseptic necrosis, especially subchondrally. Much of the folded

ligamentum teres was normal both grossly and microscopically. An additional interesting feature, noted during the exploration of the hip, was that alterations in the articular cartilage were least marked at the attachment of the ligamentum teres.

## COMMENT

From experience in operations on the hip joint in which the femoral head is deliberately dislocated from the acetabulum, I have learned that, whereas most of the time the ligament is torn, not at all infrequently, particularly if manipulations have not been sudden or violent, the head can be pried out or eased out of the acetabulum without rupturing the ligamentum teres. It is possible, therefore, to visualize a traumatic dislocation of the hip without rupture of the ligamentum teres. That must have been the case with the patient whose history is here recorded. The force producing the dislocation tore the capsule and its blood vessels, thereby depriving the femoral head of a large source of its blood supply. As a result of this there ensued an aseptic necrosis with collapse of the bony

structure, arising from too early weight bearing. One might, of course, postulate that the ligamentum teres had been torn but that the fragments had fortuitously come accurately and intimately in contact after the reduction and had reunited. But in such an event, which is extremely unlikely, there would remain at least some scars of healing, and none were visible.

## SUMMARY

In an instance of proved aseptic necrosis of the femoral head following traumatic dislocation of the hip, the important finding was a normal ligamentum teres, which proves that rupture of the ligamentum teres is not a constant occurrence in a traumatic dislocation and that typical aseptic necrosis of the femoral head may occur even though its blood supply through the ligamentum teres has not been disturbed.

## A REVIEW OF UROLOGIC SURGERY

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(Concluded from page 74)

### BLADDER

*Tumor.*—Rathbun and Wehrbein<sup>28</sup> state that lymphosarcomatous tumor of the urinary bladder is rare; data on only 5 cases have been reported previously. The case they reported was of a woman, 64 years of age, who gave a history of recurrent cystitis. Cystoscopy revealed two round tumors in the right side of the base of the bladder and two small ones on the left lateral wall. The bladder was opened, and the tumors were excised with fulgurating current. The histologic diagnosis was lymphosarcoma of the bladder.

*Hourglass Deformity.*—Zellermayer and Carlson<sup>29</sup> state that true congenital hourglass bladder is a definite entity and is caused by some regular malformation in the development of the embryo. The bladder is divided into two portions, one above the other, so that it has the shape of an hourglass. In some instances the ureters open into the upper segment and in other instances into the lower segment.

Three hypotheses have been advanced to explain the formation of congenital hourglass bladder, all of which seem plausible—atavistic relationship to hourglass bladder normally found in some animals, persistence of the embryonic

ureteric membrane and unequal growth of the two vesical anlagen.

Usually it is the symptoms of cystitis that bring the patient to the physician. Many patients give a history of lifelong vesical disturbance. These symptoms include difficulty of urination, dysuria or history of enuresis.

Congenital hourglass bladder can be recognized readily by cystoscopic examination. When the cystoscope is introduced into the bladder it is seen that the bladder is divided into two compartments, one above the other. The opening between the two segments may vary from 1 cm. to 5 or 6 cm. in diameter. The upper segment is seen to contain normal trabeculations and vascular markings, while the walls of the lower segment are smooth. The capacity of the hourglass bladder without secondary inflammation is that of the normal bladder. When acute cystitis is present, the capacity is limited. The constricting band separating the two segments is thick and does not present a sharp edge, seen in cases in which there is a diverticulum. The band also is seen to extend around the anterior vesical wall and does not blend into the lateral walls of the bladder. The ureters may open into the upper segment.

The treatment of congenital hourglass bladder should be directed toward the enlargement of the opening between the two halves of the hourglass, so as to allow better drainage and more complete emptying of the bladder. In 11 of 22 cases collected from the literature, some opera-

28. Rathbun, N. P., and Wehrbein, H. L.: Lymphosarcoma of the Urinary Bladder, *J. Urol.* **51**:31-36 (Jan.) 1944.

29. Zellermayer, J., and Carlson, H. E.: Congenital Hourglass Bladder, *J. Urol.* **51**:24-30 (Jan.) 1944.



# COMPLETE RUPTURE OF THE SUPRASPINATUS TENDON

## A SIMPLIFIED OPERATIVE REPAIR

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Complete rupture of the supraspinatus tendon is not only a relatively common lesion but an extremely painful one. In spite of this, the diagnosis is seldom made and the condition suffers from general neglect. Several instances will be cited in proof of this statement. In May 1943, a study was made of the records of a fine orthopedic clinic. These records covered fifteen years, and in them were listed six hundred and fifty varied types of painful shoulders. The diagnosis of complete rupture of the supraspinatus tendon was not made in a single case. This finding aroused great curiosity, and as a result personal conversations were held with twenty leading orthopedic surgeons in the middle and far west in the eight months that followed. Without a single exception, they readily admitted never having made the diagnosis of complete rupture, and consequently they had never seen or repaired such a rupture. In contrast, in the clinical material that is the basis of this report 3 cases of complete rupture of the supraspinatus tendon were found in a series of only 51 cases of painful shoulder.

The present status of complete rupture of the supraspinatus tendon cannot be accurately evaluated without attempting to correlate several conflicting factors. The startling frequency of this condition can be recognized by noting various postmortem studies on the shoulder joint, including those made by Meyer, Codman and Akerson and by Keyes, and the latest, made by Wilson and Duff. As two of these (Codman and Akerson<sup>1</sup> and Wilson and Duff<sup>2</sup>) were in practically complete agreement as regards incidence of lesions, the findings in these studies will be combined and reviewed.

The article by Wilson and Duff was written in somewhat greater detail than that by Codman and Akerson. The combined findings showed

that after the 30 year age limit between 30 and 40 per cent of 225 unselected bodies had demonstrable lesions in the supraspinatus tendon. In one-half the bodies, or 15 to 20 per cent of all shoulders, the lesion was large (complete rupture). With large scale rupture there are often two accompanying lesions: one, loss of hyaline cartilage from the humeral head; the other, tendinitis or concomitant rupture of the tendon of the long head of the biceps muscle. Both articles agreed that the latter lesion is never found without accompanying rupture. Degenerative lesions become more frequent and severe with advancing years. In the second article it was mentioned that differential stains demonstrated degenerative changes in the supraspinatus tendon, which antedate and predispose to subsequent rupture.

Personal experience may shed light on this discrepancy, namely, clinical lack of recognition as opposed to an amazing frequency observed post mortem. Only recently has it been realized that all too frequently this condition has bizarre symptoms which do not correspond in any way to the classic postulates for diagnosis laid down by Codman. Other observers have also noted this. Prior to five years ago, in most cases the correct diagnosis was not even suspected. It was finally realized that any chronic monarticular painful shoulder should be explored if it failed to respond to prolonged conservative treatment. Even this did not solve the problem. At first, the investigation was made through the inadequate anterior or lateral muscle-splitting incision, recommended by Codman and others. Owing to the invariable presence of dense bursal adhesions, neither of these incisions permits adequate investigation of the anterior, middle and posterior compartments. The incision now used for exploration has initiated proper recognition of the pathologic process, and it will be described in considerable detail, with the operative technic used in case 1.

As a result of these articles and a variety of clinical experiences, an attempt should be made to reconcile these postmortem observations with pathologic and clinical concepts as they concern

From the Orthopedic Service, Cedars of Lebanon Hospital, Los Angeles.

1. Codman, E. A., and Akerson, I. B.: The Pathology Associated with Rupture of the Supraspinatus Tendon, *Ann. Surg.* 93:348 (Jan.) 1931.

2. Wilson, C. L., and Duff, G. L.: Pathologic Study of Degeneration and Rupture of the Supraspinatus Tendon, *Arch. Surg.* 47:135 (Aug.) 1943.

rupture of the supraspinatus tendon. With advancing years, degenerative changes occur in connective tissue, just as they do in other tissues. But, owing to the focal action of certain components of force, as shown in the accompanying illustration (fig. 1), they are present in aggravated form at the central portion of the supra-

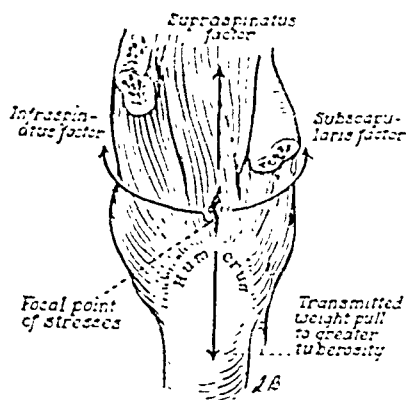


Fig. 1.—Diagram illustrating the two horizontal and the two vertical components of force. By continuous action on this focal point they combine to keep the capsulotendinous sheet taut at this point. This tends to cause degenerative lesions, which in turn lead to varying degrees of rupture. To the humerus factor must be added the weight supported by the hand and forearm.

spinatus tendon just above its point of final attachment to the horizontal line of the greater tuberosity of the humerus. The presence of this weakened area predisposes the tendon to small rupture when it is subjected to slight trauma and to large scale rupture when greater forces are applied. Once rupture occurs, there is retraction of the edges, owing to the pull of these four components of force. It can also be demonstrated on the operative table that dependency of the arm aids in keeping the rent open. Physiologically ineffectual attempts to repair this defect result in a piling up of connective tissue. This is aggravated, and complete healing is blocked by movements of the shoulder joint. In this scar tissue and in the defect, there is often a deposition of calcium. This represents an abortive frustrated attempt at healing. As a result, throughout the entire adjoining area there is chronic inflammatory reaction. The lateral surface of the lesion is the subacromial bursa and is an integral part of this zone. Therefore, this particular portion is chronically inflamed and becomes technically the seat of subacromial bursitis (fig. 2B). It could just as correctly be termed periarthrititis.

In large scale rupture, there are other factors. The loss of the central capsular support must cause a certain amount of sagging of the head of

the humerus. This should transmit increased weight to the tendon of the long head of the biceps muscle, the sole central survivor. This overstrain causes chronic inflammation (tendinitis), which in time results in a fraying or flattening of the tendon. The end result is rupture, which, as has been mentioned, is always coupled with tears of the supraspinatus tendon. Long-continued chronic inflammatory reaction about the large rent inevitably leads to loss of bordering cartilage from the articular surface of the head of the humerus. This is arthritis. This sequence of pathologic events has led to the current clinical ideas on which are based the diagnosis and the treatment of varying types of rupture of the supraspinatus tendon (fig. 2B).

It is well recognized that the late Dr. E. A. Codman<sup>3</sup> gave the first significant description of both small and large scale rupture of the supraspinatus tendon. Careful study of this monograph would seem to indicate that he observed less than a dozen cases of complete rupture, whereas in the same volume he listed hundreds of cases of incomplete rupture. These clinical statistics do not correspond in any particular with his postmortem studies, which revealed large scale rupture and small scale rupture with approximately equal frequency. He noted that in the presence of complete rupture the patient found it impossible to abduct the arm.

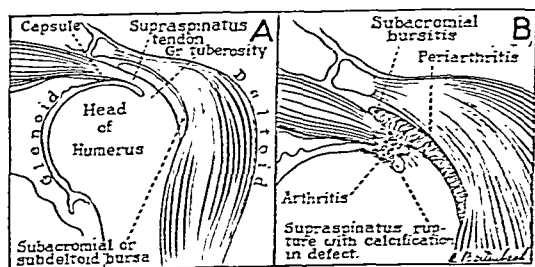


Fig. 2.—A, diagrammatic cross section illustrating the anatomic interrelation between the head of the humerus, supraspinatus muscle, supraspinatus tendon, capsule, subacromial bursa and deltoid muscle. The tendons of the capsular muscles fuse with the capsule just before final bony insertion to form a conjoined tendon (musculotendinous cuff). It is in this structure that the varying types of rupture occur. B, illustration indicating the lesions that follow and complicate rupture of the tendon. Abnormal calcification, subacromial bursitis, periarthrititis, arthritis and bicipital tendinitis are usually not clinical entities but sequelae.

From this observation, it was theorized that the normal function of the supraspinatus muscle is to stabilize the head of the humerus in the glenoid cavity so that the deltoid muscle may exert its full force of leverage against a firm

3. Codman, E. A.: *The Shoulder*, Boston, The Author, 1934, p. 156.

base. Later, Watson-Jones supported and illustrated this.<sup>4</sup> This has given rise to what is known as the deltoid-supraspinatus synergistic theory. All previous operative procedures, with the exception of those of Bosworth and McLaughlin, have been based on this hypothesis and the belief that the supraspinatus muscle must be recovered and restored to its normal position if any degree of normal function of the shoulder is to be obtained.

Codman also was the first to describe an operation for the repair of complete rupture. He recommended that the tendon be exposed by means of the "saber cut" incision, this being a transverse incision over the upper surface of the shoulder. The acromioclavicular joint is severed, the acromion process is cut through and reflected and the tendon is recovered and sutured with silk. In this portion of his monograph, the subject matter is most confusing. In one place he mentioned "the saber cut which gives a perfect exposure," and a few pages later he stated that "this incision has been given up as certain cases developed instability of the joint following operation." He was far from satisfied with the end results in these cases, and, on page 261, he stated: "On the whole the outcome of cases with complete rupture is relatively poor." He expressed the opinion that this was due to the fact that the patients were seen later.

The next reparative operation was that of Wilson.<sup>5</sup> He wrote a paper containing an extensive summary of the cause and pathologic features of complete ruptures of this nature. In it are many acute observations, such as that the lesion occurred from slight or minimal trauma. He also recognized that the injury occurred in shoulders in which there had previously been degenerative changes. The exposure he used was similar to that of Codman. The tendon was pulled down and by means of a fascia lata suture was inserted into a bony trough on the lateral surface of the upper end of the humerus. Ten cases in all were reported, with apparently excellent end results.

The next operative modification was reported by Mayer.<sup>6</sup> This at first was similar to the one described by Wilson, but after 3 cases he noted, as a result of the splitting of the deltoid muscle, development of severe weakness of the anterior

fibers of this muscle. He stated the belief that this was due to injury to the anterior branch of the axillary nerve. In his last case he used the incision to be described subsequently. He further advised immobilization of the arm in abduction after operation.

Another procedure was recommended by Bosworth.<sup>7</sup> In addition to giving an excellent classification for small rents, he recommended arthrodesis and fusion of the shoulder for large rupture. As has been noted previously, none of these operations has been frequently used.

The latest operative procedure for correction of rupture of the supraspinatus tendon was recently described by McLaughlin.<sup>8</sup> His procedure differs from the preceding in that, although the supraspinatus tendon is recovered, he places strong emphasis on restoration of capsular continuity rather than on complete anatomic reposition. From a series of 3,000 painful shoulders treated at the Presbyterian Hospital in New York in the past ten years he found 32 complete ruptures and 8 massive avulsions. His method of exposure is similar to that of Codman, but the reparative procedure differs from others in that the lesion is closed from side to side instead of from end to end and the various edges are fastened to the lateral surface of the humerus by means of drill holes and sutures. His reported end results were good.

In 3 cases complete rupture of the supraspinatus tendon was repaired by an operative procedure which differs radically from any that have been previously described. Because of this, it will be necessary to describe the rationale that led to these changes. In previous articles attention has been called to the fact that the head of the humerus may be resected when made necessary by irreducible fracture dislocation or severe comminution of the head of the humerus. If the capsule attached to the head is discarded, the condition known as "flail shoulder" results in almost 50 per cent of the cases. If, however, the capsule is reattached to the outer upper end of the shaft by means of bony grooves, a stable shoulder is the inevitable result. When these grooves are arranged to follow the physiologic pattern, stability is accompanied by almost complete functional recovery. This is a practical demonstration that the capsule of the shoulder joint as it attaches

4. Watson-Jones, R.: Injuries in the Region of the Shoulder Joint: Capsule and Tendon Injuries, *Brit. M. J.* 2:29 (July 2) 1938; Fractures and Other Bone and Joint Injuries, Baltimore, Williams & Wilkins Company, 1940.

5. Wilson, P. D.: Complete Rupture of the Supraspinatus Tendon, *J. A. M. A.* 96:433 (Feb. 7) 1931.

6. Mayer, L.: Rupture of the Supraspinatus Tendon, *J. Bone & Joint Surg.* 19:640 (July) 1937.

7. Bosworth, D.: Supraspinatus Syndrome: Symptomatology, Pathology and Repair, *J. A. M. A.* 117:422 (Aug. 9) 1941.

8. McLaughlin, H. L.: Lesions of the Musculotendinous Cuff of the Shoulder: I. The Exposure and Treatment of Tears with Retraction, *J. Bone & Joint Surg.* 26:31 (Jan.) 1944.

to the upper end of the humerus represents a dual structure, the capsule and the fused tendons of the "short rotator" muscles. It was only a short step to speculate that if function could be restored in the face of great anatomic defects it should be relatively simple where the defect is much less.

Before proceeding to detail certain physiologic observations that led to the changed operative procedure, it will be necessary to review certain key points of the surgical anatomy of the shoulder joint. Should a more detailed and illustrated description be desired, it can be found in a preceding article.<sup>9</sup>

The "short rotator" or capsular muscles, for this purpose, are considered as three, rather than four. Proceeding backward these are: the subscapularis, the supraspinatus and the infraspinatus teres minor muscle. All of these fuse with the capsule of the shoulder joint before final bony insertion to form a conjoined tendon (fig. 2A). This structure has been given a special name, "the musculotendinous cuff" (Codman). The supraspinatus and infraspinatus teres minor muscles arise from the posterior surface of the scapula and at this point are separated by the spine (base) of the acromion process. In their outer half, they fuse to become a continuous musculotendinous sheet under the recess of the projecting acromion process. The fibers of the supraspinatus muscle insert into the transverse line of the greater tuberosity, while the fibers of the infraspinatus teres minor muscle insert into the posterior descending line. The subscapularis muscle arises from the anterior surface of the scapula, and the tendon winds anteriorly to insert into the lesser tuberosity of the humerus and a line which can best be defined as the anterior border of the bicipital groove. By fascial prolongation, they finally insert into the anterior descending line of the greater tuberosity. The continuous line of the greater tuberosity, because of its shape (an inverted U), has been termed the "horse shoe." These key points of surgical anatomy should be borne in mind, as only the lower edges of these structures can be seen after reflection of a flap of deltoid muscle and in the presence of an intact bony acromioclavicular arch. Further, they differentiate right and left (fig. 1).

Mention has already been made of the physiologic concept that governed previous operative procedures. The simplified operative repair is based on an altered idea as to the function of the capsular muscles.

The reconstructive operation that was mentioned affords sufficient evidence to support the contention that the major function of the capsular or "short rotator" muscles, acting as a group, is to stabilize the head of the humerus in the glenoid cavity. In short, working together they constitute the real antagonist for the deltoid muscle. In support of this hypothesis, it has been noted that the combined weight of the groups is approximately the same as that of the deltoid muscle. Further, they lie under and approximate the shape of the deltoid muscle to such an extent that Codman once spoke of them as the "inner deltoid."<sup>10</sup>

Attention has been called to the fact that the supraspinatus muscle is small when compared with its neighbors, the subscapularis muscle in front and the infraspinatus teres minor muscle in back. When these three muscles are completely excised and weighed, the supraspinatus muscle weighs only one seventh of the total. The relatively small size of the supraspinatus muscle has been confirmed in a recent article, in which it was stated that it weighed only a little more than one twentieth as much as the total scapulohumeral musculature.<sup>11</sup> Because of the small size of the supraspinatus muscle, it seemed reasonable to surmise that the complete loss of abduction which frequently followed complete rupture could not be due to the loss of the supraspinatus muscle alone. A muscle weighing 65 Gm. could not be the sole antagonist for the deltoid muscle, which weighs seven times as much. Anatomic dissections also had revealed that these powerful muscles in front and in back pull not only against their bony insertion but against each other through the central link of the conjoined tendon (musculotendinous cuff). This is the tendon of the supraspinatus muscle. Consideration of these facts led to the conclusion that the very presence of this central rupture produced inaction of the neighboring muscles, the subscapularis muscle in front and the infraspinatus teres minor muscle in back. Each of these muscles weighs three times as much as the supraspinatus muscle.

From the preceding anatomic and physiologic observations, it seemed feasible that a flap be borrowed from the contiguous visible upper portion of the infraspinatus muscle and transplanted as a substitute for the ruptured and retracted tendon of the supraspinatus muscle. Then, by suturing the edges of this transplant to the muscles in front

10. Codman, E. A.: Personal communication to the author.

11. Inman, V. T.; Saunders, J. B. deC. M., and Abbott, L. C.: Observations on the Function of the Shoulder Joint, *J. Bone & Joint Surg.* 26:1 (Jan.) 1944.

9. Jones, L.: The Shoulder Joint: Observations on the Anatomy and Physiology, *Surg., Gynec. & Obst.* 75:433 (Oct.) 1942.

and in back capsular continuity would be re-established. This theory of restoration of capsular continuity, however accomplished, has recently been given powerful support by McLaughlin, although his method of operative repair differs radically.

Where the defect was large, with the rent extending into the neighboring muscles, as in complete avulsion of the upper capsular segment,

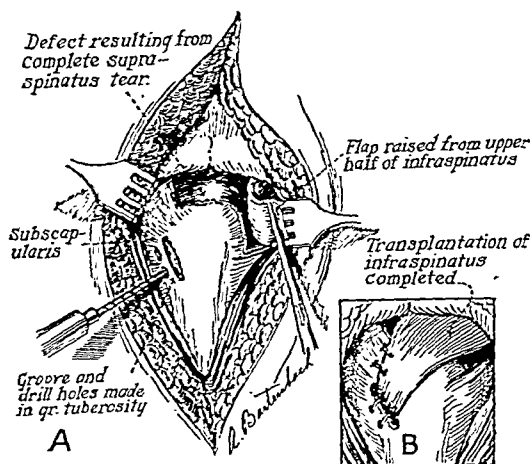


Fig. 3.—*A*, diagram illustrating simple complete rupture of the supraspinatus muscle of the left shoulder, with retraction of the tendon. A flap from the upper portion of the visible infraspinatus muscle is substituted for the retracted supraspinatus muscle and swung into a bony groove with entrant drill holes. *B*, diagram illustrating complete transplantation and linking of the flap to the muscles in front and back, thus reestablishing capsular continuity. Fixation was obtained with silk sutures, although fascia sutures are preferable.

two flaps were borrowed, one from the infraspinatus and the other from the subscapularis muscle. A small amount of muscle power is lost by failure to recover the supraspinatus muscle. Avoidance of the difficulties and postoperative complications attendant on its recovery compensates for this. Further, additional purchase (muscle power) is obtained by inserting the transplant farther down on the shaft of the humerus. Certain diagnostic and surgical information can best be conveyed by a study of the following case reports.

#### REPORT OF CASES

**CASE 1.**—Mrs. T. J., a housewife aged 26, was first seen on Dec. 5, 1941. Her chief complaint was pain in the left shoulder of over seven years' duration. The past history revealed that seven years before this date she was thrown from a truck. Immediately thereafter she noted pain in the left shoulder, and this persisted with only slight variation up to the time when she was first seen by me. The patient was examined by four different orthopedic specialists and one group of orthopedists during this period. All made diagnoses of sub-

acromial bursitis and treated her conservatively. On irrigated the bursa under local anesthesia for one or one-half years. Another recommended application of plaster spica, to be followed by physical therapy. Her latest treatment consisted of the following: physiotherapy and massage thrice weekly and an abductor splint to be worn during the daytime only. Two manipulations, with the patient under anesthesia, were performed, both of which aggravated the pain for approximately six weeks. Examination revealed the following conditions: There was slight flattening of the posterior portion of the deltoid muscle as compared with the opposite side. When she was asked to point to the most painful area, the index finger was placed over the attachment of the subscapularis tendon. On abduction, acute pain was experienced at the 70 degree angle. After this angle was passed, localized pain on pressure disappeared (Dawbarn's sign). External rotation caused acute pain, and internal rotation caused much less. Muscle power was good when not limited by pain (fig. 4*A*). Roentgen examination gave negative results. The preoperative diagnosis was incomplete or partial rupture of the supraspinatus tendon.

Operation was performed on December 15. Because of their importance, the operative position and incision used will be described in detail. The patient was placed on the side and an assistant assigned to hold the forearm during the operative procedure. This position is essential to adequate exposure of the posterior compartment. Further, manipulation (rotation) is essential during the operative procedure to facilitate fixation and closure.

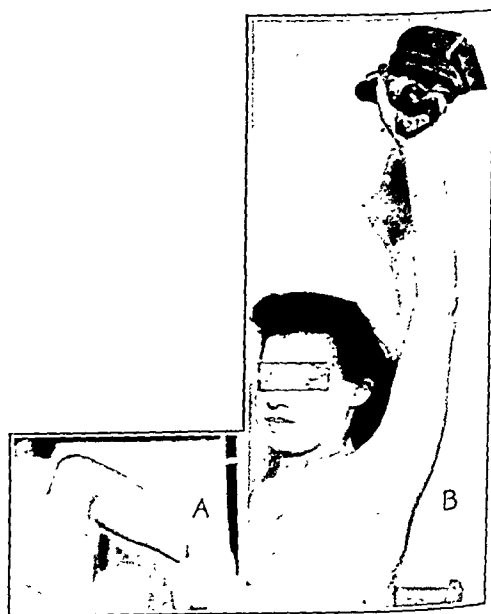


Fig. 4.—*A*, photograph (case 1) illustrating bizarre symptoms accompanying a simple complete rupture of seven and one-half years' duration. The patient had ability to abduct and fair muscle power but severe pain from this point up to the 90 degree angle and extreme pain on external rotation. *B*, postoperative photograph illustrating complete recovery, as evidenced by a painless shoulder, with complete return of function. The patient is now able to extend her arm completely and to elevate the flatiron to the overhead position.

The incision used has been variously attributed to Cubbins and co-workers, Henry, Thompson, and Mayer.<sup>12</sup> Investigation, however, reveals that Cubbins and associates gave the first complete description of it as it is used at present. It will therefore be spoken of as the Cubbins or "acromioclavicular" incision.<sup>12a</sup> Should a more detailed and completely illustrated description be desired, one is referred to the original article. A 6 inch (15 cm.) vertical cutaneous incision is made on the anterior surface of the humerus, just external to the

is then inserted into the muscular interspace between the pectoralis major and the deltoid muscle and the deltoid muscle is elevated. It is then separated close to its final attachment to the clavicle, the acromioclavicular joint and the acromion process. At this point, which is well above all branches of the circumflex nerve, the deltoid muscle is relatively avascular. The anterior two thirds of the deltoid muscle is reflected downward as a flap. This is difficult, as these lesions are invariably accompanied by dense bursal adhesions.

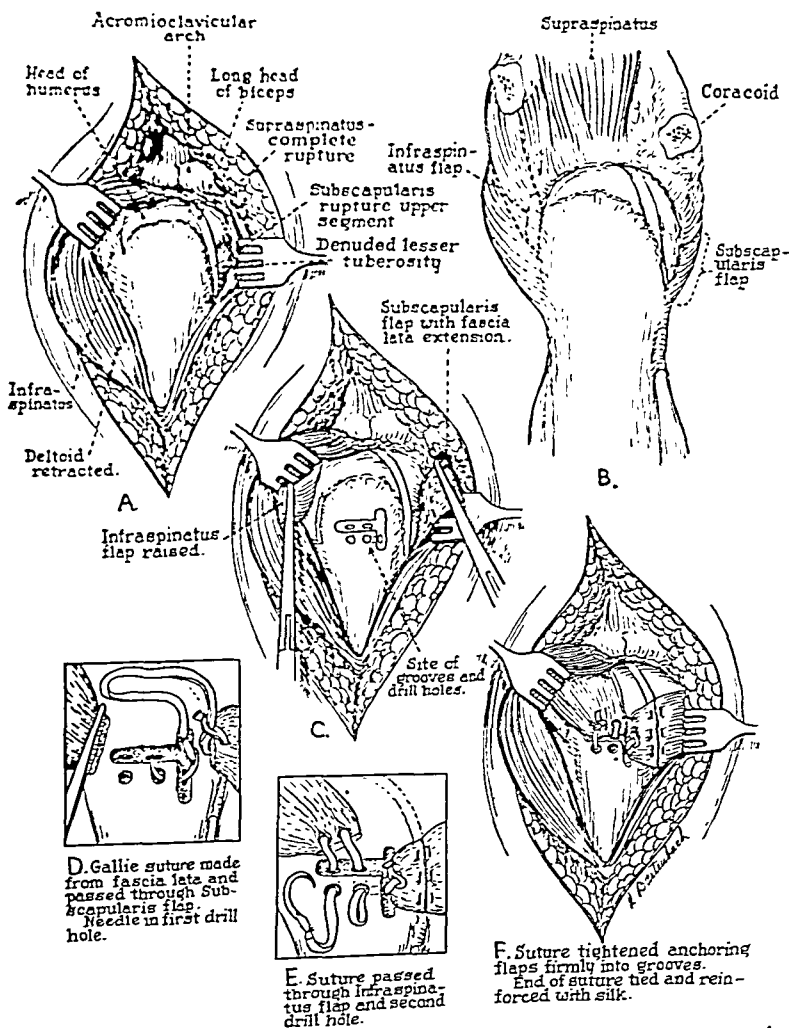


Fig. 5.—A, drawing illustrating complete rupture of the supraspinatus tendon, with extension of the tear into the upper portion of the infraspinatus and the subscapularis tendon. Anteriorly, the tendon of the long head of the biceps muscle is divested from all its attachments and the lesser tuberosity is denuded. Posteriorly the tear extends into the upper portion of the infraspinatus tendon. B, diagram illustrating the outline of the posterior and anterior flaps used to repair complete avulsion of the upper segment before separation. For illustrative purposes, all overlying structures (deltoid muscle, outer end of clavicle and acromion process) have been removed. C, illustration of a T-shaped trough on the lateral upper surface of the humerus and a right angle anterior two way drill hole. The two flaps are now separated preparatory to transplantation. The subscapularis tendon has been lengthened by a fascial tab. D, diagram illustrating steps in the use of the running fascia lata suture, which is inserted into the bony groove with entrant drill holes. E, relation of the fascia lata suture to the bony tunnels and troughs. By this means, closure can be made with a single running suture.

coracoid process. It is then turned laterally and continued just external to the semicircular curve of the bony acromioclavicular arch. The incision should pass well to the posterior surface of the shoulder joint. The flap of skin is then reflected downward, exposing the deltoid muscle. The index finger

In view of the clinical findings, the pathologic changes were surprising. The upper transverse line of the greater tuberosity was completely bare of any tendinous attachment, indicating complete rupture of the supraspinatus tendon with retraction (fig. 4 A). The tear did not extend into the capsular tendons of the neighbor-

ing muscles. The bursa was injected and chronically inflamed, and the inner and outer layers were adherent at many points. The tendon could not be pulled down without cutting through the acromioclavicular arch. To

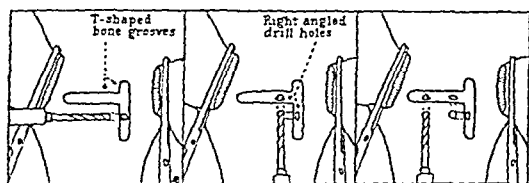


Fig. 6.—Serial diagrams illustrating the steps in preparing T-shaped bony grooves and the exact manner of preparation of entrant drill holes.

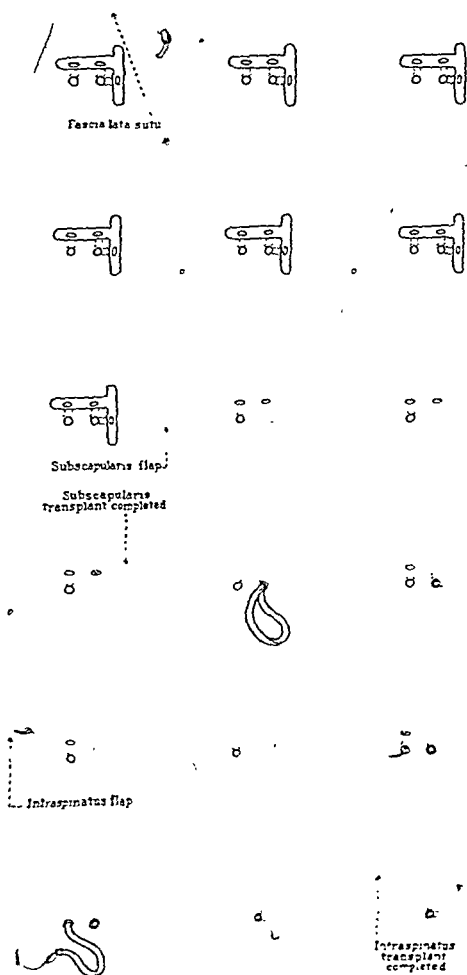


Fig. 7.—Serial diagrams illustrating the steps in transplantation of a double flap, with a single running Gallie suture. The flap from the subscapularis muscle is always placed in the vertical groove and the flap from the infraspinatus muscle in the transverse groove.

avoid this, a 1 inch (2.5 cm.) segment of the neighboring and visible infraspinatus muscle was separated from its bony attachment and mobilized. A transverse groove 1 inch (2.5 cm.) long was made on the lateral surface

of the humerus just below the transverse line of the greater tuberosity. The groove was placed so that its axis was at right angles to the direction of the muscle fibers of the transplanted flap. Two entrant drill holes were made at each end and at right angles to the ends of the groove. The infraspinatus muscle transplant was then fixed into the groove by means of silk sutures. The edges of the transplant were then sutured to the neighboring muscles, in front and in back, in order to reestablish continuity (fig. 3 B). A previous prepared abduction splint, with the arm maintained at the 60 degree angle, was applied. After four months the patient had complete return of function, as shown in figure 4 B.

CASE 2.—J. E. G., aged 70, was injured while carrying a bucket of water. The accident occurred Feb. 1, 1942. He slipped and fell, and in his doing this his arm was bent backward and under the body. Immediately after the injury, he found that he was unable to abduct his arm. He was referred to a physician and given physical therapy, consisting of heat and massage. He attempted to return to work on two occasions and finally was suspected of malingering. The first examination was made on June 15, 1942. Examination revealed that the patient was unable to initiate abduction, although he could feebly flex and extend the arm at the shoulder joint. An abduction splint was prescribed and was worn at the 45 degree angle six weeks before operation. After two weeks he was able to abduct the arm to the 45 degree angle but this movement was always accompanied by great pain. Both external and internal rotation were severely limited and painful. Atrophy of the deltoid muscle was severe. There were no areas of sensory anesthesia.

Operation was performed on July 29. The position and the incision were similar to those described in case 1. Once the deltoid muscle had been reflected, a crescentic tear was visualized, which started at a point just anterior to the upper portion of the bicipital groove. It then extended posteriorly to include that upper portion of the subscapularis muscle which inserts into the lesser tuberosity, and farther posteriorly to include the entire supraspinatus tendon and the upper 1 inch (2.5 cm.) of the insertion of the combined capsular-infraspinatus teres minor muscles. The tendon of the long head of the biceps muscle ran through the middle of the defect, completely devoid of attachments (fig. 5 A). This is the type of lesion that usually is described as a complete avulsion. It would be better described as a complete tear of the upper segment of the capsule. From the anterior edge of the bicipital groove the retracted but still visible upper portion of the subscapularis muscle was recovered and a 1 inch (2.5 cm.) flap prepared (fig. 5 B). At the posterior end of the tear, the retracted infraspinatus muscle was recovered with an adjoining portion of the supraspinatus muscle, and a similar flap was made. Two bony grooves, one transverse and the other at right angles to the anterior end, were made on the lateral surface. A Gallie fascial suture was obtained from the thigh. At the same time, a triangular tab of fascia was secured. This was sutured to the end of the tendon of the subscapularis

12. (a) Cubbins, W. R.; Callahan, J. J., and Seuder, C. S.: The Reduction of Old or Irreducible Dislocations of the Shoulder Joint, *Surg., Gynec. & Obst.* 55: 129 (Feb.) 1934. (b) Henry, A. K.: Exposures of the Long Bones and Other Surgical Methods, *Bristol: John Wright & Sons, Ltd.*, 1927. (c) Thompson, J. E.: Anatomical Methods of Approach in Operations on the Long Bones of the Extremities, *Ann. Surg.* 69: 339 (Sept.) 1918. (d) Mayer.<sup>2</sup>

muscle, to lengthen it. This is necessary, as it is frequently too short for fixation without tension (fig. 5 F). The anterior flap was fixed into the anterior groove and the posterior flap into the vertical groove. Entrant drill holes were made at right angles to the grooves, as shown in the figures (fig. 5 C). Closure was made with a running suture which is difficult to describe but simple when illustrated (figs. 5 D, E and F, 6 and 7).

The edges of the various flaps were then sutured to each other and to the remaining muscles in front and in back, and thus continuity was reestablished. The patient's arm was again placed in the previously worn abduction splint at the 45 degree angle. Owing to the advanced age of the patient and the chronicity and severity of the lesion, recovery was slow. For fear of lost fixation, no movement was permitted for six weeks. After this period, gradual increasing active motion was encouraged. This was first done by loosening the straps that fixed the arm and forearm to the brace and then encouraging abduction exercises on the splint. Later stretching and rotating exercises increased the range of motion. The patient was last seen in July 1943 and at that time had a completely painless shoulder, although abduction could be brought only to the 60 degree angle. He was able to carry a 20 pound (9 Kg.) sandbag at the extreme range of his abduction.

CASE 3.—In this case the accident occurred on June 30, 1942, when the patient fell 18 feet (5.5 meters) from a scaffold. The patient was a robust man 60 years old. There was immediate and severe pain in the right shoulder. He could not initiate abduction, and there



Fig. 8.—A, photograph of the patient in case 3, taken before operation, illustrating inability to initiate abduction, with extreme pain on slight rotation. B, photograph taken after operation illustrating painless shoulder and range of abduction and external rotation. C, photograph taken after operation illustrating painless shoulder and ability to carry 20 pounds (9 Kg.) of sandbags with the arm at the 60 degree angle of abduction.

was pain on pressure over the entire upper end of the humerus. When the arm was slowly and passively abducted, the painful pressure point disappeared. The rotatory movements were acutely painful. When preliminary immobilization gave little relief, operative repair was advised and performed on August 24. Avulsion of the upper capsular segment was found, which was similar and only slightly less extensive than that described in the preceding case. The operative pro-

cedure was similar in every particular. When last seen, in July 1943, he was able to abduct his arm to the 90 degree angle and place his hand in back of his head with only slight discomfort at the extremes of rotation. He could carry 20 pounds (9 Kg.) of sandbags with the arm fully abducted. The patient was well pleased and was able to do farm work (fig. 8).

#### EVALUATION

Most men especially interested in the shoulder joint are aware of the fact that there is much confusion as regards both diagnosis and treatment. Codman, whose works are generally considered authoritative, recognized this condition in the following words<sup>2</sup>:

The reader who has the patience to finish this book will inevitably remain confused about the lines of distinction which I have attempted to draw among the six most common clinical entities which affect the shoulder, i. e., complete and incomplete tendon ruptures, rim rents, calcified deposits, tendinitis and arthritis. In fact, I must leave the reader puzzled, for I am still puzzled myself.

This statement is as true today as when it was first made. This can be verified by a study of a recent article by Wilson,<sup>12</sup> which listed considerably more than one hundred references, all taken from the literature of the past twenty years. A study of these articles indicates that there is complete disagreement regarding every diagnostic and therapeutic phase as they pertain to painful shoulder.

This paper has attempted to correlate many conditions that are now considered as separate entities. As an example, abnormal calcification about the shoulder is considered as positive proof of the present or past existence of rupture. The present impression is that it is found only in incomplete small tears. It must be freely admitted that clinical statistics in recent articles and in this paper on the incidence of complete rupture are probably much too low. The fact that post-mortem examination finds large rents in the capsule in 15 to 20 per cent of the bodies whereas clinical studies of even a large number of patients have failed to reveal any such frequency needs explanation. As in case 1, many of these patients are treated conservatively with varying diagnoses for years. It may even be that after a lapse of years they may become relatively free from pain by a process of adaptation. The patient learns to avoid certain positions which have been found to be painful.

In line with the preceding comments, critical issue must be taken with two statements that are made regarding rupture of the supraspinatus

13. Wilson, C. L.: Lesions of Supraspinatus Tendon. Arch. Surg. 46:307 (March) 1943.



tendon. The first is that the lesion never occurs under the 30 year age level. The initial injury in the first case described in this article occurred at the age of 19. In another case of partial rupture the patient was 26 years old when operated on. The second statement that should be critically reviewed is that this is a self-limited disease of only two years' duration. In the first case in this series there was a history of pain for seven and one-half years. In another the patient had a history of pain of seventeen years' duration.

As regards the use of the Cubbins exploratory and operative incision that has been described, it is my belief that it should be adopted universally. It affords adequate exposure for almost any operative procedure about the shoulder that can be brought to mind. Of even more importance is the fact that splitting of the deltoid muscle is avoided and with it injury to branches of the circumflex nerve. It is difficult to explain why it should be so rarely used.

The operative procedure that has been described, namely, the use of substitution flaps, has given me confidence, not formerly possessed, in my ability to cope with large scale rupture.

As an experiment in pathologic physiology, study of these cases before and after operation affords powerful support for a hypothesis that has been previously advanced.<sup>9</sup> It is as follows:

"Movement of the shoulder demands both fixation of the glenoid and the head of the humerus, with effort increasing the demand. Two distinct muscle systems are involved in effecting this. Dysfunction of any (single) muscle component will seriously disturb the fine muscle balance (in other components) essential to normal shoulder movement."

#### CONCLUSIONS

Complete rupture of the supraspinatus tendon is a common lesion. Although it is rarely diagnosed clinically, postmortem statistics show that it is found in 15 to 20 per cent of the shoulders of unselected cadavers after the age of 30.

Subacromial bursitis, abnormal calcification, periarthritides, monarticular arthritis of the shoulder joint and rupture of the tendon of the long head of the biceps muscle are frequently not clinical entities but are complications and sequelae that accompany and mask rupture of the supraspinatus tendon.

The lesion occurs under the 30 year age level and is not a self-limited disease of only two year duration.

Chronic painful shoulders that do not respond to conservative treatment should be more frequently explored, with the Cubbins transacromioclavicular incision. With it two indispensable prerequisites are met. It affords sufficient exposure for the recognition of pathologic lesions. At the same time adequate surgical exposure is given for the immediate repair of the varying types of rupture of the supraspinatus tendon that are disclosed.

Three cases of complete rupture were found in a series of 51 cases of chronically painful shoulders. In 1 case the condition was a simple rupture which involved the supraspinatus tendon alone and in 2 there was complete rupture involving not only the supraspinatus but portions of the adjoining tendons as well.

The method of repair described avoids cutting through the bony acromioclavicular arch. Not only is postoperative instability avoided, but there is considerable saving in operative time.

Postoperative results indicate that pain and loss of function following complete rupture of the supraspinatus tendon are due not to the defect per se but to a disruption of capsular continuity. The loss of this supraspinatus link seriously affects the function of the more important neighbors, the subscapularis and infraspinatus teres minor muscles.

Restoration of capsular continuity, however accomplished, is followed by relief from pain and great improvement in function.

9615 Brighton Way.

## PROGRESS IN ORTHOPEDIC SURGERY FOR 1943

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY  
OF ORTHOPAEDIC SURGEONS

### XVI. CONDITIONS INVOLVING THE LOWER PART OF THE BACK

PREPARED BY HAROLD H. KUHN, M.D., DURHAM, N. C.

A review of the papers published during 1943 on pain in the lower portion of the back and sciatica shows the continued interest of American writers in posterior herniation of intervertebral disks. Most writers present a review of previous papers, modifications in operative technic and follow-up statistics. The use of contrast mediums for myelography finds fewer advocates.

Deery<sup>535</sup> discusses herniation of the nucleus pulposus as a complication of preexisting instability of the lower part of the back. He divides patients with sciatic pain into three general groups: (1) those with sciatic pain only, (2) those with sciatic pain and minimal pain low in the back and (3) those with a history of disability in the lower portion of the back preceding the development of sciatica. He describes the typical history, signs and symptoms and outlines diagnostic measures. Lumbar puncture was carried out for all patients treated by the author, but he does not recommend the use of contrast mediums. He describes the development of operative treatment and points out that generally fusion alone for instability will not relieve sciatic pain. He recommends for patients of groups 2 and 3 fusion combined with excision of the ruptured intervertebral disk.

Hyndman, Steindler and Wolkin<sup>536</sup> discuss herniated intervertebral disk and the use of myelography with iodized poppyseed oil and the procaine test in the differential diagnosis. Two general types of patients are covered in this paper: (1) those definitely having root compression with sciatic neuritis and (2) patients with myofascial syndromes which provoke reflex sciatica. Sixty-three laminectomies were done for ruptured intervertebral disks, and 50 herniated disks were found. Ninety-two per cent were found at or below the fourth or fifth lumbar

interspace. The authors used myelography with iodized poppyseed oil in only the atypical cases. One patient had a negative result with iodized oil but a disk was found. Three patients had clinical signs and symptoms of a ruptured intervertebral disk, but on exploration no ruptured disk was found. Five patients showed filling defects, but on exploration no ruptured disks were found. The operation is dealt with in detail, and they sound a note of caution against too minimal exposure, particularly when exploration is made on the basis of clinical findings only and without the aid of studies with iodized oil. When "trigger points" are present, the authors recommend the injection of 1 per cent procaine hydrochloride, which generally will relieve the pain low in the back as well as the sciatic neuralgia. The authors point out that the procaine test is a differentiating point between sciatic pain from referred sources and direct pressure mechanism, such as is seen with ruptured intervertebral disks. When the procaine test eliminates the "trigger area" as well as the pain over the area of distribution of the sciatic nerve, they recommend further conservative treatment.

Ver Bruggen<sup>537</sup> reports on 75 patients with pain low in the back and sciatica, 66 of whom had ruptured intervertebral disks. Ninety-three per cent of these occurred at the fourth and fifth lumbar interspaces, with 58 per cent at the latter. There were three disks between the third and fourth lumbar vertebrae, one between the fifth and sixth and one with multiple herniations. The author states that he has seen 8 cases of complete herniation which produced complete paraplegia, simulating a transverse lesion of the cauda equina. He discusses the anatomic and pathologic features of herniated nucleus pulposus and presents statistics on signs, symptoms and findings. Sixteen injections of iodized poppyseed oil were made, with three positive

535. Deery, E. M.: Herniation of the Nucleus Pulposus as a Complication of Preexisting Low Back Pain, *Surg., Gynec. & Obst.* **77**:79-86 (July) 1943.

536. Hyndman, O. R.; Steindler, A., and Wolkin, J.: Herniated Intervertebral Disk: A Study of the Iodized Oil Column, the Procaine Test in Differential Diagnosis from Reflected Sciatic Pain, *J. A. M. A.* **121**:390-401 (Feb. 6) 1943.

537. Ver Bruggen, A. H.: Herniated Nucleus Pulposus: A Report of Seventy-Five Cases Examined and Operated on by One Observer, *Dis. Nerv. System* **4**:165-177 (June) 1943.

errors and two negative errors. Twenty-three injections of air were made, with six positive errors. No contrast medium was used in 27 of the 66 cases, and no errors were made. He reports that the results were excellent in 15 per cent of his cases, good in 68 per cent, fair in 11 per cent and poor in 6 per cent.

McEachern and Cone<sup>538</sup> review the symptoms and findings in patients with ruptured intervertebral disks in the fourth and fifth lumbar areas. They point out that hyperalgesia is occasionally found in the lower portion of the back and report cases in which there was referred pain into the flank and abdomen, which needed thorough gastrointestinal and genitourinary studies. The authors believe that the referred pain may be due to intersegmental nerve supply to the dura and the ligamentous structures. Determinations of protein were done on spinal fluid withdrawn below the protrusion in 24 cases. Three samples of 3 to 4 cc. were collected in separate tubes, and the protein content was compared to that found in control cases. A greater drop in the protein level from the first to the third sample was noted in the control cases. The results were too scattered to permit use of this method as a reliable clinical tool.

Haynes<sup>539</sup> reports 21 cases of ruptured intervertebral disk at the Lovell General Hospital. Eleven of the patients were discharged from the Army because the changes existed prior to enlistment. Ten patients were operated on, 9 of whom returned to full military duty and 1 of whom was discharged from the Army because of psychoneurosis. The author states that the percentage of cures in the military services must be high if surgical treatment is to be justified. He stresses conservatism, accurate diagnosis, elimination of psychoneurotic patients and careful care before and after operation. The author believes that in selected cases 90 per cent of patients who have been operated on can return to full military combat duty. He reports an average disability of six weeks.

Echols<sup>540</sup> describes the surgical treatment of ruptured intervertebral disks. He presents indications, operative technic and results from combined disk fusion operations. The author operated on 170 patients, 100 of whom he describes as having excellent results.

538. McEachern, D., and Cone, W. V.: *Clinical Points on Ruptured Intervertebral Discs: Low Back Pain and Sciatica*, *Canad. M. A. J.* **49**:33-35 (July) 1943.

539. Haynes, W. G.: *Problem of Herniated Nucleus Pulposus in the Military Service*, *War Med.* **3**:585-595 (June) 1943.

540. Echols, D. H.: *Surgical Treatment of Sciatica Due to Rupture of an Intervertebral Disk*, *S. Clin. North America* **23**:1335-1353 (Oct.) 1943.

Young<sup>541</sup> discusses the etiologic factors of painful back. He divides the patients into four main groups: (1) those with pain referred from abdominal or pelvic viscera and with full range of painless motion in spine and hips and (2) those patients with pain due to local condition of the back, arising from: (a) muscles, fascia and ligaments, (b) nerves and perineural structures, (c) intervertebral and sacroiliac joints and (d) bones, which are inflammatory, traumatic or involved in Paget's disease. He gives statistics on 770 patients, both civilian and military. Diagnostic tests and treatment are described. Brailsford, in a conjoint paper, calls attention to roentgenographic interpretation of the vertebral column and the adjacent soft tissue structures. He discusses recognition of alteration in the individual parts as the responsible pathologic condition.

Hare and Langs<sup>542</sup> discuss pain low in the back and sciatica, with special reference to roentgen interpretation. Anatomic abnormalities are discussed in detail, with emphasis on roentgenographic interpretations. A method of oxygen myelography is given in detail. After injection, the table is immediately tilted downward 30 degrees, and stereoscopic exposures are made with the patient in the true lateral position with the painful side uppermost. Anteroposterior views and a 45 degree view of the lumbar sacral angle are then made. After injection of oxygen, there is a period of twenty minutes for roentgen examination, before the oxygen disappears. This method was used in 100 consecutive cases in the New England Baptist Hospital with 85 per cent accuracy. The authors believe that there is a definite decrease in postoperative headaches following this procedure.

Breck and Basom<sup>543</sup> describe flexion treatment for pain in the lower part of the back in patients who have narrowed fourth or fifth lumbar interspaces. This treatment is based on the observations of Love, Walsh and Schachtel, who noted that in dissected specimens kyphotic flexion caused the protruded disk to be drawn in and that hyperextension of the spine caused the disk to protrude farther. Treatment consists of placing the patient in bed

541. Young, R., and Brailsford, J. F., in *Discussion on Painful Back in Soldiers and in Industrial Workers*, *Proc. Roy. Soc. Med.* **36**:211-218 (March) 1943.

542. Hare, H. F., and Langs, L. W.: *Low Back Pain and Sciatica with Special Reference to Roentgen Interpretation*, *U. S. Nav. M. Bull.* **41**:1263-1272 (Sept.) 1943.

543. Breck, L. W., and Basom, W. C.: *The Flexion Treatment for Low-Back Pain: Indications, Outline of Conservative Management, and a New Spine-Fusion Procedure*, *J. Bone & Joint Surg.* **25**:58-64 (Jan.) 1943.

in a semisitting position, with flexion of the lumbar portion of the spine, the hips and the knees. Physical therapy with flexion exercises accompanies this treatment. Inexpensive apparatus which can be used in the home is illustrated. For those patients needing surgical treatment, they describe a modified spinal fusion operation in which bone grafts are placed across the laminal arches in the customary fashion. After subluxation of the facets has been reduced and the interspaces restored to normal, if fusion is indicated the customary fusion is carried out and an H-shaped bone block is placed between the spinous processes of the involved vertebrae. The additional graft is used to prevent subluxation of the facets and postoperative narrowing of the intervertebral space. The authors report on 2 patients on whom this procedure was carried out, with good results. [ED. NOTE.—A similar procedure has been described by Bosworth.]

Stewart and Owen<sup>544</sup> report changes in the intervertebral disk at the third lumbar vertebra in a patient with a history of repeated spinal puncture. They discuss the possibility of perforation of the annulus fibrosis with escape of nuclear material, leading to collapse of the intervertebral disk and subsequent changes in the bodies of the vertebrae. They refer to 4 similar cases reported by Everett and Epps. The patient gained relief from symptoms by rest alone for eight weeks.

Fisher<sup>545</sup> reports a case of pain low in the back with radiation into both lower extremities, which was accentuated by chiropractic manipulation. A large ruptured fifth lumbar intervertebral disk was removed. [ED. NOTE.—I have observed 2 similar cases and believe that any forceful extension of the spine is likely to produce this injury.]

Hiss<sup>546</sup> makes a plea for examination of the feet in all cases of pain in the lower portion of the back. He states that of 80,000 patients whose feet were examined in his clinic 40,000 had backache and that in 50 per cent of these the pain in the back was due to foot disorders.

Hershey<sup>547</sup> calls attention to osteoarthritis of the sacroiliac joint and its relationship to pain

of sciatic radiation. Dissections were carried out on 64 cadavers, and the lumbosacral portion of the trunk was found to be in direct contact with the sacroiliac joint where it traverses the joint in its lower third. Osteoarthritis was found in only 25 per cent of the sacroiliac joints studied. The upper portion of the origin of the pyriformis muscle was found to lie medial to the lumbosacral portion of the trunk in all cadavers but never to lie between the trunk and the joint. He believes that the changes observed would produce direct irritation of the lumbosacral portion of the trunk.

Pitkin<sup>548</sup> summarizes the results in 53 patients who were operated on for instability of the lumbosacroiliac joints by means of fusion of the lumbosacral area, which he described in 1937. The operation is a modification of the Verrall tie rod graft. The author states that his operation offers the advantage of immediate immobilization without any form of external support. Seventy per cent of the patients had good anatomic and functional results, 20 per cent were moderately improved and 10 per cent were classed as anatomic and functional failures. [ED. NOTE.—This seems to require extensive and detailed grafting when a more simple fusion would be adequate.]

Thiltgen<sup>549</sup> reviews the anatomy of the lumbosacral plexus. He reports a series of sacral epidural injections and describes the technic used. He points out that toxic manifestations may occur and that death has followed entrance of the solution into the subarachnoid cavity or into the blood stream.

Vinke and White<sup>550</sup> studied roentgenograms of the lumbosacral area in 300 children between the ages of 5 and 15. They found only 3 cases of narrowing of the lumbosacral joint which could be considered congenital. They state that Williams in his series found only 1 case of narrowing of the lumbosacral joint which could be considered congenital. The authors report on 6 adult patients with narrowing of the lumbosacral joint in whom pain was attributed to other causes. The roentgenograms which revealed narrowing showed associated anomalies, with partial and bilateral sacralization. They conclude that a narrowed lumbosacral joint may be a

544. Stewart, V. A. F., and Owen, A.: A Case of Arthritis of the Lumbar Part of the Spine Following Lumbar Puncture, *M. J. Australia* 2:295-296 (Oct. 9) 1943.

545. Fisher, E. D.: Report of a Case of Ruptured Intervertebral Disc Following Chiropractic Manipulation, *Kentucky M. J.* 41:14 (Jan.) 1943.

546. Hiss, J. M.: Backaches and Feet, *Hahneman. Monthly* 78:385-391 (Sept.) 1943.

547. Hershey, C. D.: The Sacro-Iliac Joint and Pain of Sciatic Radiation, *J. A. M. A.* 122:983-986 (Aug. 7) 1943.

548. Pitkin, H. C.: Internal Brace for the Low Part of the Back, *Arch. Surg.* 46:755-758 (May) 1943.

549. Thiltgen, W. S.: Sacral Epidural Injection of Normal Saline in the Treatment of Sciatica. Certain Cases of Low Back and Pelvic Pain (with Case Reports), *M. Rec. & Ann.* 37:688-689 (Nov.) 1943.

550. Vinke, T. H., and White, E. H.: Congenital Narrowing of the Lumbosacral Space, *Surg., Gynec. & Obst.* 76:551-555 (May) 1943.

congenital anomaly and does not necessarily indicate injury to the intervertebral disk.

Hoge<sup>551</sup> discusses pain in the lower portion of the back from the viewpoint of a gynecologist. The author presents numerous statistics on pelvic conditions which produce pain low in the back, their treatment and the results. He describes the gynecologic cause of backache and urges women with backache to have a gynecologic investigation.

McBride<sup>552</sup> discusses nonskeletal injuries to the lower part of the back. He calls attention to postural strain or sprain of the ligaments in the iliolumbar, lumbosacral or sacroiliac areas. The author emphasizes accurate localization and points out the distinguishing characteristics and customary tests.

Steindler<sup>553</sup> stresses accuracy in localization of pain on an anatomic ligamentous basis. He discusses pain low in the back where "trigger points" are located. He explains pain on a basis of stretch to the ligaments. He mentions the value of injection of procaine hydrochloride to differentiate true sciatica or sciatic neuritis from referred pain. Emphasis is given to accuracy in localization of the lesion.

Herzmark<sup>554</sup> reports a case of herniation of the cauda equina following laminectomy on the sacrum for removal of iodized poppyseed oil. The herniation was reduced and the sacral defect repaired with fusion of the lumbosacral area. Use of iodized poppyseed oil and laminectomy for its removal are considered inadvisable.

551. Hoge, R. H.: Low Backache from the Viewpoint of the Gynecologist, *Virginia M. Monthly* 70: 598-601 (Dec.) 1943.

552. McBride, E. D.: Nonskeletal Low Back Injuries, *M. Rec. & Ann.* 36:238-241 (Feb.) 1942.

553. Steindler, A.: Las lumbalgias; su diagnóstico, *Día méd.* 14:900-904 (Sept. 7) 1942.

554. Herzmark, M. H.: Herniation of Cauda Equina Following Laminectomy of Sacrum, *J. Bone & Joint Surg.* 25:197-201 (Jan.) 1943.

Wilensky<sup>555</sup> calls attention to the anatomic relationship of muscles, fasciae, ligaments, blood vessels and nerves in the region of the pelvic outlet. He discusses their possible relation to pain low in the back, sciatica and coccygodynia. He confirms Thiele's report that spasm of the levator ani, coccygeus or piriformis muscle causes such symptoms. Relief is obtained by massage of these muscles. The author presents 8 illustrative cases of 28 studied.

Toumey<sup>556</sup> presents a study of 95 cases of metastatic cancer of the spine, from a total of 2,067 cases of cancer. Roentgenograms frequently fail to reveal metastasis, particularly in the early stage. During a four year period (1936 to 1940) 326 cases of mammary carcinoma were observed, and in 42 the patient showed spinal metastasis. Of 140 cases of prostatic carcinoma, associated spinal metastasis occurred in 11. Hodgkin's disease of the spine was encountered in 7 cases. He discusses palliative therapy. Roentgen therapy often relieved pain and allowed local repair. Subarachnoid injection of alcohol is subject to complications and frequently does not relieve pain. Chordotomy is advisable for inoperable conditions. Orchiectomy deserves further trial for advanced carcinoma of the prostate.

Schumacher<sup>557</sup> discusses the evaluation of disability due to injuries to the lower part of the back. He discusses McBride's and Kessler's methods for computing disability and presents disability charts of specific injuries. [Ed. Note.—The charts show all components of disability and are valuable references.]

555. Wilensky, T.: Levator Ani, Coccygeus and Piriformis Muscles: Agents in Causation of Coccygodynia, Superior Gluteal Pain and Sciatic Syndrome, *Am. J. Surg.* 59:44-49 (Jan.) 1943.

556. Toumey, J. W.: Metastatic Malignancy of the Spine, *J. Bone & Joint Surg.* 25:292-305 (April) 1943.

557. Schumacher, F. L.: Evaluation of Disability in Low Back Injuries, *Radiology* 41:18-22 (July) 1943.

## XVII. INFECTIONS OF BONES AND JOINTS

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McIntosh and Selbie<sup>558</sup> point out that in a previous paper they showed the value of sulfonamide drugs in preventing gas gangrene in mice under certain conditions. This report is based on a further study of the subject, in which they used zinc peroxide, proflavine and penicillin on experimental animals.

558. McIntosh, J., and Selbie, F. R.: Zinc Peroxide, Proflavine and Penicillin in Experimental Clostridium Welchii Infections, *Lancet* 2:750-752 (Dec. 26) 1942.

They point out that the clostridia are in the nesting stage when the wound is infected and that only through the use of some inciting agent, which would appear to be the calcium ion, is the organism capable of producing an infection. In their experiments toxin-free clostridia were used, and with the calcium chloride present they produced both a local and a general infection. With this technic, they found that in local infection zinc peroxide is apparently of no value in preventing the development of *Clostridium welchii*.

infection in mice after the organisms have invaded the tissues.

Proflavine was of greater value than sulfanilamide and as good as sulfathiazole for local prophylaxis. Its use as a dressing for wounds warrants further investigation. Penicillin injected at the site of infection within three hours after the infection is a powerful prophylactic and superior to proflavine or sulfonamide compounds. *Ed. Note.*—This is an interesting and useful paper. It is hoped that the authors will continue his experimental work.]

Scheman, Lewin, Sideman and Janota<sup>559</sup> report on a method of producing osteomyelitis in rabbits and dogs by intrametaphyseal injection of sodium morrhuate and *Staphylococcus aureus* one week after administration of immunizing doses of the organism. They were able to produce panosteitis. The clinical course in the animals ran from the acute to the chronic stage in three weeks and closely resembled the human variety. If no organisms are injected complete regeneration of bone occurs about three and one-half weeks after injection of sodium morrhuate. The authors contend that in man as well as in animals the earliest lesion in osteomyelitis is damage to bone tissue, and in none of their animals was there any evidence of vascular thrombosis from sodium morrhuate. In none of their animals did sinuses develop without surgical treatment, although some were allowed to die from the osteomyelitis itself. They suggest that in human beings septicemia rather than bacteremia may be a valuable criterion for withholding surgical operation. They conclude with an outline of proposed experiments which should be helpful in evaluating the various therapeutic approaches to the problem of osteomyelitis. [*Ed. Note.*—This work opens up a most practical method of producing osteomyelitis that clearly simulates the infection in human beings.]

Weaver and Tyler<sup>560</sup> produced staphylococcal septicemia in 205 rabbits, with resultant hematogenous osteomyelitis in 39 per cent. This report is based on their difficulties and conclusions. Young rabbits, 6 to 8 weeks old and weighing 500 to 750 gm., were found best suited for this study, for they were considered of an age comparable to the first decade in childhood. A twenty-four hour broth culture of hemolytic *Staph. aureus*

(0.02 cc.) was intravenously inoculated into 205 rabbits. No roentgenographic or microscopic studies were made, but 147 macroscopic abscesses of bone were found in 80 of these rabbits, with about 80 per cent occurring in the metaphyseal area. The complications encountered, which, they note, are rare in human beings, were frequent convulsions, massive hemorrhage distributed especially in the muscle tissue and an occasional attack of pneumonia.

They conclude that while the availability and the cost of the rabbit make it a convenient animal, a sturdier animal is more desirable. The authors feel that sulfathiazole in the experiment was of little value. All of the rabbits had non-operative therapy. [*Ed. Note.*—No conclusions can be satisfactorily drawn from this study, but it is of value in recording the difficulties which the authors found in a study of this sort.]

Gage<sup>561</sup> states that the early high mortality in acute osteomyelitis is caused from profound toxemia, with or without bacteremia. Since in over 83 per cent of cases acute osteomyelitis is due to *Staph. aureus*, its necrogenic toxin and its toxin with a "spreading factor" must cause extensive destruction of the osseous tissues. Bacteremia is probably due to bacterial thrombophlebitis in osseous tissue. He classifies the types of acute osteomyelitis according to the extent of systemic and local osseous involvement, which depends on the type of organism and its toxin. The profound systemic reaction so often seen in acute osteomyelitis is due to diffuse cellulitis of bone and bone marrow and lymphangitis.

The author advocates for treatment the usual general measures plus administration of sulfathiazole and antistaphylococcus serum, 60,000 to 100,000 units daily, immobilization of the involved parts and operation only when the cellulitis has localized with formation of an abscess. He states that any operation during the acute stage results in high mortality and serious disability. He cites cases reported by Butler in which the patients with positive blood cultures who were operated on early showed twenty-five times the mortality of those with negative cultures. [*Ed. Note.*—No data are given on the results of treatment as outlined to compare with the results of other methods. The author mentions Butler's cases in which there is only a 2 per cent mortality with early operation and no administration of sulfonamide drugs or staphylococcus antitoxin.]

559. Scheman, L.; Lewin, P.; Sideman, S., and Janota, M.: Experimental Osteomyelitis, *Am. J. Surg.*:371-380 (June) 1943.

560. Weaver, J. B., and Tyler, M. W.: Experimental staphylococcal and Hematogenous Osteomyelitis, *Bone & Joint Surg.* 25:791-802 (Oct.) 1943.

561. Gage, M.: Acute Hematogenous Osteomyelitis, *J. Pediatr. Surg. & Obst.* 76:123-124 (Jan.) 1943.

Brown and Ghormley<sup>562</sup> discuss 24 patients with the diagnosis of solitary eccentric (cortical) abscess in bone, 87 per cent of whom were under 30 years of age. The tibia and the femur were the commonest sites of involvement, but the fibula, radius, os calcis and patella were also involved. The clinical picture was characterized by the following: pain, generally chronic, often nocturnal and well localized; localized swelling and induration; minimal physical findings, with limping when the lesion was near a joint. The roentgenogram, almost pathognomonic, showed a small radiolucent lesion within or beneath the cortex or in the osteoplastic reactive portion of the periosteum and uniform osteosclerosis around the lesion. The pathologic finding on operation was chronic inflammation with fibrous tissue and scattered giant and round cells. Many patients showed obliteration of blood vessels in the region of the lesion. The treatment was not uniform, but two thirds of the patients had surgical excision of lesions with definite relief; 1 had irradiation with relief after a year; 1 improved with rest in bed. Two thirds of the patients had a history of trauma and focal infection or focal infection alone; cultures made from lesions for 2 patients yielded *Staph. aureus* and for 2 others micrococci. None of the lesions showed microscopic evidence of tumor.

Banerjee<sup>563</sup> classifies acute osteomyelitis into three main groups: (1) hematogenous osteomyelitis, (2) osteomyelitis due to infection from without and (3) osteomyelitis due to secondary invasion from neighboring tissues. He describes the pathologic and histologic features, and discusses the four possible types of process, including reaction to injury, formation of abscess, separation of dead from living tissue and repair. In hematogenous osteomyelitis, inflammation usually starts from the epiphyseal line, the infection starting from the medulla, spreading through the cortex and finally reaching the epiphyseal line, where an abscess is formed. The joints are seldom affected. Progress of the involvement depends mainly on the condition of the nutrient vessel. Osteomyelitis due to infection from without may involve only the periosteum, or, if the infection lasts long, it may affect the bone. Severe infection may spread along the medulla, and serious general infection may occur. In osteomyelitis due to infection from contiguous tissue, the peri-

osteum may be separated from the bone resulting complete degeneration or thinning of the bone. If the intensity of the infection surrounding tissue is low, proliferating osteomyelitis with thickened bone or spicules may develop. [ED. NOTE.—The spread of the infection to the adjacent joint is largely determined by the location of the metaphyseal area, whether capsular or extracapsular.]

Simpson<sup>564</sup> discusses the anatomy and histology of bone as related to the pathogenesis of acute osteomyelitis. The factors favorable for localization of a pathologic process in growing bone are summarized as follows: 1. The cellular structure. Actively growing bone is more cellular, with a resultant greater concentration of calcium ions and variation in  $pH$ . 2. The physicochemical structure. In growing bone, the fibrils are coarse and irregular, the bone cells are large and numerous, and the loose connective tissue is more prominent in the marrow spaces and in the surrounding irregular trabeculae of bone. This is in contrast to adult bone, which has a definite form and a basic unit (Haversian system). The principle of its structure is a central vascular system about which there is bony substitution. Thus the metaphysis is in a more direct relationship to the circulation than is the cortex, which is more or less sequestered. 3. The blood supply. The metaphysis has a more abundant supply of blood than cortical bone. Before fusion of the epiphysis the so-called end arteries are present. A septic embolus obstructing one of these vessels causes a triangular area of necrosis from which the process extends toward the center of the osteum. 4. The lymphatic supply of bone. There is a lymphatic plexus in the periosteum which probably takes part in the pathogenesis of localization.

Stewart<sup>565</sup> reports that by using concentrated *Clostridium perfringens* toxoid suspended in physiological saline, combined immunization, as evidenced by antitoxin titrations, has been demonstrated both in guinea pigs and in human beings. The antitoxin response to tetanus toxoid is greater when the toxoid is given in combination with *Cl. perfringens* toxoid than when it is given alone. According to previous work, guinea pigs so immunized show ability to withstand large doses of a living culture of *Cl. perfringens* inoculated intramuscularly. On the basis of animal experiments there is reason to believe that the same ability

562. Brown, R. C., and Ghormley, R. K.: Solitary Eccentric (Cortical) Abscess in Bone. *Surgery* 14:541-553 (Oct.) 1943.

563. Banerjee, D. N.: Pathology of Acute Osteomyelitis in the Child. *Indian M. Rec.* 63:111-116 (April) 1943.

564. Simpson, D. B.: Studies on Pathogenesis of Acute Hematogenous Osteomyelitis. *Mil. Surgeon* 43:50 (Jan.) 1943.

565. Stewart, S. E.: Active Immunization of Human Beings with Combined *Clostridium Perfringens* and Tetanus Toxoids. *War Med.* 3:503-511 (May) 1943.

might be demonstrated in human beings in whom chance infection probably does not involve many spores. Antibody responses were studied in guinea pigs and in 21 human subjects.

McMilan<sup>566</sup> says that gas gangrene must be considered as a possibility in compound fractures, soil-contaminated wounds, extensive lacerations or crushing wounds and after abdominal operations. Roentgenograms should be taken of involved areas every four or six hours after injuries from which gas gangrene is likely to develop. This will lead to early diagnosis. The surgeon should not wait for clinical signs and symptoms. Prophylaxis consists in immediate débridement. Use of sulfanilamide in the wound, administration of adequate doses of tetanus-gas gangrene antitoxin and possibly roentgenographic examination. Active therapy consists of (a) application of 100 r over the involved areas as soon as the diagnosis is made or strongly suspected, with repetition of the dose twice daily for three days or until the infection is controlled; (b) local débridement; (c) administration of therapeutic amounts of antiserum if the infection is more than twelve hours old or if the patient does not respond clinically to the preceding treatment. Amputation for gas gangrene per se should not be resorted to. Four hundred and fifty-four cases have been collected, in 416 of which roentgen therapy was used. There was a 14.9 per cent mortality rate (62 deaths), as compared with 49.7 per cent in Miller's 607 collected cases in which roentgen therapy was not given. [Ed. Note.—The mortality rate in this series is striking, and I am in agreement with the treatment outlined by the author.]

Dennis<sup>567</sup> describes the treatment of acute osteomyelitis in 122 patients under 21 years of age. Three methods were used: (1) Hoyt's method—rest in bed with administration of sulfathiazole only, (2) Orr's treatment—saucerization of bone, packing of the wound with petrolatum gauze and application of a cast and (3) conservative immobilization—conservative operative procedures when indicated, with supportive measures, including immobilization in casts. Most of the patients with chronic osteomyelitis were treated in an expectant fashion. Sequestrectomy was performed when drainage or fever increased and roentgenographic evidence of sequestrums was present. Both the Orr treat-

ment and primary closure after saucerization with administration of sulfathiazole were employed. Prolonged dependent drainage with drains made of lucite (polymerized methyl methacrylate) was also used. It is concluded that acute osteomyelitis in young children is more benign than in older persons. Also, prolonged rest in bed, plaster fixation and oral administration of sulfathiazole are the most effective measures in the early acute stage. In the chronic disease, the choice lies between saucerization, implantation of sulfathiazole, primary closure and plaster or prolonged dependent drainage with tubes made of polymerized methyl methacrylate.

Holzwarth<sup>568</sup> reports 2 cases of gas bacillus infection in which he feels that the use of zinc peroxide dressings proved highly effective.

Abozin<sup>569</sup> describes an experimental study on cadavers to determine the roentgenographic appearance of gas introduced into the muscles of the limbs or along fascial planes. He discusses the use of roentgenograms in the diagnosis of gas gangrene and in the prognosis, including indications for amputation. He concludes that they are of great value in these respects but must not be used as a sole criterion.

Muscolo<sup>570</sup> emphasizes the fact that in its early stages Ewing's sarcoma roentgenographically resembles subacute or chronic osteomyelitis and in its later stages acute osteomyelitis. He describes 5 cases in detail to illustrate the difficulties in differential diagnosis. In 2 cases it was impossible to distinguish between the two conditions. In a third case final differentiation was possible only by biopsy puncture, which was done according to the technic described by Valls and co-workers.

Pinkus and Zlatkin<sup>571</sup> report a case of tertiary syphilis in a 30 year old Negro woman who was suffering from cutaneous lesions and painful swelling of the left ankle. She had been receiving antisyphilitic treatment for several years. Roentgen examination showed that the lower end of the tibia was involved. There was thick-

568. Holzwarth, F. K.: Zinc Peroxide: Valuable Adjunct in Treatment of Gas-Bacillus Infection and Traumatic Wounds, *J. Bone & Joint Surg.* 25:177-184 (Jan.) 1943.

569. Abozin, V. G.: Early Radiological Diagnosis of Gas Gangrene, abstracted, *Bull. War Med.* 3:311 (Feb.) 1943.

570. Muscolo, D.: Ewing Sarcoma and Osteomyelitis: Difficulties of Diagnosis, *Rev. Assoc. méd. argent.* 57:599-603 (Aug. 30) 1943.

571. Pinkus, H., and Zlatkin, L.: Tertiary Syphilis of Skin and Bone Co-Existing with Granulomatous Halogen Skin Eruption, *J. Michigan M. Soc.* 42:269-273 (April) 1943.

566. McMilan, K. D.: Gas Gangrene; Analysis of Four Hundred and Sixteen Collected Cases Treated by Roentgen Therapy with Thirteen New Cases, *West. J. Surg.* 51:187-192 (May) 1943.

567. Dennis, C.: Experience with Hematogenous Osteomyelitis in Children at University of Minnesota Hospitals, *Journal-Lancet* 63:134-137 (May) 1943.



ening of the bone and the periosteum, with circular areas of rarefaction in the regions of increased density. When antisyphilitic therapy was discontinued (as a therapeutic test) the pain and the swelling increased. Roentgenograms showed changes in the tibia, which became irregular, and there was eburnation. When antisyphilitic treatment was again instituted, improvement followed after six weeks, the swelling of the leg subsided and the patient was free of pain.

Weingart, Wirtz and Irving<sup>572</sup> report a case of monilial osteomyelitis in a 10 year old Negro. The patient had been suffering from thrush since the age of 6 weeks. Three weeks prior to admission to the hospital, the child fell, and since that time he had complained of a painful left hip. Except for the granular whitish coating of the mouth and pharynx, examinations, including roentgenographic studies, revealed no abnormalities. The patient was treated by rest in bed and traction. At the end of three months a roentgenogram of the hip showed slight rarefaction of the head and neck of the femur with no acetabular involvement. A Mantoux tuberculin test gave negative results. A hip spica was applied. After two months, the outer aspect of the thigh showed fluctuant swelling. A roentgenogram showed further rarefaction of the head and neck. Pus aspirated from the abscess showed *Monilia albicans*. The same organism was dominant in the mouth.

Rankin and Eger<sup>573</sup> report a case of acute osteomyelitis in a 14 year old boy whose blood culture revealed staphylococci. There was a history of trauma one week prior to admission to the hospital. There were extreme tenderness and slight swelling on the anterolateral aspect, near the epiphysis, of the lower third of the right thigh. Roentgenograms taken on the third and the thirteenth day after the onset revealed no abnormality. The patient was treated by hot packs, immobilization and blood transfusion. He received sulfathiazole. On the fourteenth day the temperature and the pulse were normal. On the eighteenth day administration of the drug was discontinued. On the twenty-fourth day the patient was discharged ambulatory. A roentgenogram taken three months after the onset appeared normal, and the patient was well. [Ed. NOTE.—Without any roentgenographic evi-

dence of change in bone one wonders why this case should be classed as one of osteomyelitis.]

Flynn<sup>574</sup> reports 100 cases of acute suppurative tenosynovitis of the hand, of which results were bad in 47 per cent and good in 33 per cent. In comparison with results reported thirty years previously, Flynn's results show no improvement. He discusses anatomic bacteriologic considerations in connection with treatment. In no case of this series did infection come from the blood stream or the lymphatic system. The most important single factor in production of poor results was delay in operation. Incisions should be adequate to drain the pocket of pus, with care being exercised to avoid injury to the adjacent structures and herniation of the tendon. It is important to observe a sterile aseptic technic and to avoid mixed infection. Sulfonamide drugs used locally and systemically seem to minimize the incidence of severe complications. Patients should be hospitalized until the infection has subsided.

Kernwein and Capps<sup>575</sup> briefly review the literature and report on a 24 year old white woman in whom typhoid due to osteomyelitis of the ulna developed three months after she had contracted typhoid, which was treated with sulfaguanid. The local lesion in the ulna was excised, packed with sulfathiazole and closed without drainage. The wound healed per primam. Cultures of excised marrow revealed typhoid bacilli. Microscopic observations are described. The authors discuss draining sinuses of osteomyelitis due to typhoid as a source of contagion, which contraindicates the Orr method of treatment. They suggest that surgical excision, local application of sulfonamide drugs and closure with drainage are beneficial. [Ed. NOTE.—This is an interesting observation, and while osteomyelitis due to typhoid is rare the danger of the purulent material's being a source of contagion should be recognized.]

Impink, Denhoff and VanderVeer<sup>576</sup> report a case of hemolytic *Staph. aureus* septicemia with osteomyelitis of the femur, pericarditis, pneumonia and pleurisy in a 4 year old child who recovered with no recurrence in eight months.

574. Flynn, J. E.: Acute Suppurative Tenosynovitis of Hand, Surg., Gynec. & Obst. 76:227-235 (Feb.) 1943.

575. Kernwein, G. A., and Capps, R. B.: Typhoid Osteomyelitis: Case Report, Am. J. Surg. 60:433-44 (June) 1943.

576. Impink, R. R.; Denhoff, E., and VanderVeer, J. B.: Staphylococcus Aureus Septicemia, with Osteomyelitis, Pneumonia and Acute Purulent Pericarditis. Case Report, Am. Heart J. 26:699-703 (Nov.) 1943.

572. Weingart, J. S.; Wirtz, D. C., and Irving, N. W.: Monilia Osteomyelitis: Report of Case Resulting from Thrush, Am. J. Clin. Path. 12:597-600 (Dec.) 1942.

573. Rankin, L. M., and Eger, S. A.: Acute Hematogenous Staphylococcal Osteomyelitis of Femur: Successful Treatment with Sulfathiazole Without Operation, Am. J. Surg. 59:136-137 (Jan.) 1943.

The treatment consisted of: supportive measures, frequent blood and plasma transfusions and administration of sulfathiazole and sulfadiazine and of bacteriophage temporarily. Incision and drainage of the femoral abscess on the eleventh day after the onset were followed by immobilization in plaster with the Orr treatment for eleven weeks. Repeated aspiration of the pericardial sac, pericardiostomy and thoracentesis were done. Laboratory studies showed positive blood cultures until the ninth day and negative cultures of pericardial fluid until pericardiostomy, and roentgenograms of the femur revealed no abnormality until the eleventh day. [ED. NOTE.—This is an adequate study and report except that no roentgenogram of the femur was made later than one month after the patient's discharge from the hospital.]

Wilensky<sup>577</sup> reports a case of osteomyelitis of the tibia with thrombosis of the saphenous vein. He emphasizes the importance of treating bacteremia and toxemia primarily and withholding operation on the bone itself. Treatment consisted of excision of the thrombophlebitic vein to remove the main source of bacteremia. Sulfonamide compounds were given systemically. The author draws a parallel between this case and an instance of acute mastoiditis complicated by thrombosis of the internal jugular vein. Both instances indicate the importance of vascular thrombosis in the pathogenesis of foci in bone. The author believes that in most cases the extent of the focus in the bone is almost immediately determined by the character and position of the embolic thrombophlebitis, and what appears in the roentgenogram to be a spread is an increase in the amount of temporary decalcification of the diseased area. [ED. NOTE.—Wilensky's views on the treatment of acute osteomyelitis still seem too conservative to warrant their routine adoption. He draws an interesting parallel in discussing the pathogenesis of the infection of bone.]

Kanan<sup>578</sup> presents 3 cases of acute osteomyelitis of the tibia in which subperiosteal resection was the treatment employed. In all of these cases and in another in which roentgenograms could not be obtained the tibia healed under optimal conditions, with abundant regeneration of bone of good quality. The general condition improved shortly after the operation. Indications

and contraindications must be considered in each individual case. Subperiosteal resection is recommended for localized forms of acute osteomyelitis the course of which indicates a tendency to heal. [ED. NOTE.—Only in certain localities in the body would resection of the infected bone seem justifiable.]

Franz<sup>579</sup> reviews the work of Vidal on gunshot injuries of the joints in the Spanish Civil War (1,282 wounds). They were treated by drainage and immobilization alone. Good results were obtained in a majority of the patients, which suggest that resection of a joint for purposes of drainage is unnecessary. For the more extensive lesions the prognosis was not so good. Of 273 patients with gross damage near a joint, 10.2 per cent died. For 103 patients with suppuration of a joint there was a mortality rate of 26.4 per cent. He concludes that in cases of fulminating infection amputation is the only possible treatment; resection is useless. Franz favors resection and believes that the danger of infecting the bone at the site of resection has been greatly exaggerated. The causes of death after resection include poor selection of cases, insufficient preparation, delay of operation until infection has become generalized and performance of an operation on patients who are not in a fit state to spend a long time in bed.

Bugyi<sup>580</sup> states that primary infections leading to bacteremia precede clinical manifestations by a few days. The patient is not in a severe septic condition due to osteomyelitis but has acquired osteomyelitis from sepsis. With this point of view, it is logical to combat sepsis first. Beside intravenous administration of resorcinol, quinine, sulfonamide compounds, and saline and dextrose solution, local therapy is of little significance. Immobilization, elevation of the extremity and induction of hyperemia are recommended. Persistent fever and severe leukocytosis should not mislead the operator to premature surgical operation. Expectant treatment is indicated. A "fixation" abscess is awaited.

Experience is needed to choose the proper moment for surgical intervention, which must be neither too early nor too late. Subperiosteal resection is contraindicated in severe acute infections. For subacute or chronic infections this procedure may be used, but only in exceptional cases, in which the periosteum is completely

577. Wilensky, A. O.: Osteomyelitis of Tibia with Thrombosis of Saphenous Vein: Discussion of Conservative Therapy, *Pennsylvania M. J.* 46:953-955 (June) 1943.

578. Kanan, E. J.: Subperiosteal Resection in Therapy of Acute Osteomyelitis, *Arq. rio grand. med.* 20:165-180 (Oct.) 1942.

579. Franz, C.: Resection of Infected Joints, abstracted, *Bull. War Med.* 3:322-324 (Feb.) 1943.

580. Bugyi, I.: Conservative Therapy of Acute Osteomyelitis of Long Bones, *Chirurg* 14:742-745 (Dec.) 1943.

detached and the long bones surrounded with pus. [ED. NOTE.—This is a good article.]

Gellman<sup>581</sup> reports a case in which an extra-articular focus irritated the hip joint by juxtaposition, with resulting early diagnostic confusion. The patient, a 3 year old Negro girl who had been suffering from an infection of the upper respiratory tract with some abdominal pain noticed pain in her left hip two weeks later. Examination three weeks after the onset of illness, including the taking of roentgenograms, gave negative results except for an injected pharynx. The impression was pharyngitis with possible rheumatic disease. One week later the patient complained of burning on urination. The left thigh was adducted and the knee flexed. The temperature was 102 F. There were a few pus cells in the urine. A roentgenogram of the hip revealed no abnormality. The diagnosis of possible tuberculosis of the hip was made, and the patient was put in traction. There was rigidity in the left lower quadrant of the abdomen and fullness below the left inguinal ligament. The white blood cell count was 34,000. The tuberculin test with a 1:1,000 dilution gave positive results. A culture of the urine showed *Staph. albus*, but the temperature remained elevated. A diagnosis of pyelitis was made, and all tests of fluid aspirated from the hip gave negative results. Two weeks later, while the swelling above and below the ligament, which had been increasing, was being examined, the patient suddenly winced and urinated frank pus. The bladder had been perforated. Incision and drainage of the mass were performed, and similar pus was released. A culture showed *Staph. albus*. Cystograms confirmed the diagnosis of extravascular abscess. The patient recovered uneventfully. [ED. NOTE.—This is an instructive report of an unusual site for an abscess.]

Abeshouse and Gellman<sup>582</sup> discuss the pathogenesis, pathologic changes, clinical features, diagnosis and treatment of various complications of the bladder due to injuries and diseases of the pelvic girdle. A review of the literature and personal experiences with 4 cases of pelvifemoral osteomyelitis with involvement of the bladder are recorded. The authors conclude:

1. Infections of the urinary tract, particularly of the bladder, are relatively rare complications of injuries and diseases of the pelvic girdle. 2. Infection of the

581. Gellman, M.: Perforation of Bladder by Non-osseous Retroperitoneal Abscess: Report of Case, *Bull. School M. Univ. Maryland* 27:90-95 (Oct.) 1942.

582. Abeshouse, B. S., and Gellman, M.: Bladder Complications of Injuries and Diseases of Pelvic Bones and Head of Femur, *Urol. & Cutan. Rev.* 47:83-105 (Feb.) 1943.

urinary tract complicating injuries or diseases of pelvic girdle may be due to (a) an infection antedating the osseous lesion, (b) an infection occurring simultaneously and by the same organisms causing osseous lesion, (c) a subsequent infection resulting from the hematogenous transportation of organisms from osseous lesion, and (d) the direct extension of infectious process from the osseous lesion to an adjacent portion of the urinary tract. 3. The latter type of infection (2d) usually manifests itself as an infectious process in or about the bladder. The bladder complications include intravesical infection (cystitis), perivesical infection (para-osseous abscess, perivesical phlegm acute or chronic pericystitis), intramural infect (abscess of the bladder wall), intraperitoneal or extraperitoneal rupture of the bladder, osteovesical, osteocutaneo-vesical, or cutaneo-vesical fistula, calculus formation, and perforation of the bladder by fragments of bone sequestra or involucra. 4. In cases of pelvifemoral osteomyelitis, there are two characteristic signs of bladder involvement which can be readily determined by cystographic study, viz.: lateral displacement of the bladder and alterations in the outline of the bladder. 5. These bladder changes may be produced by several different lesions which originate in the osseous lesion and extend to the perivesical tissues in the bladder viz.: (a) para-osseous abscess in the perivesical tissue (b) an involucrum or sequestrum in the perivesical tissues and pressing on the bladder; (c) acute or chronic pericystitis resulting from the extension of the infectious process from the osseous lesion to the perivesical tissue; and (d) intramural abscess of the bladder secondary to the osseous lesion or perivesical abscess. 6. These lesions may lead to the development of an osteovesical fistula with or without the subsequent formation of calculi in the bladder. These lesions may also be responsible for secondary obstructive or infectious changes in the upper urinary tract as a result of an acute or chronic infectious or cicatricial process about the base of the bladder and the lower ureters. 7. Prompt surgical treatment is indicated in these cases in order to prevent or forestall the development of an osteovesical fistula or serious damage to the upper urinary tract. 8. Conservative treatment consisting of chemotherapy and supportive therapy has yielded good results in unrecognized or undiagnosed cases of para-osseous abscesses but this type of treatment is not advisable in the accurately diagnosed case for the reasons indicated above.

Lenormant<sup>583</sup> emphasizes the fact that treatment with sulfonamide drugs is only a supplement to the usual surgical procedures and not a substitute for them. He used sulfanilamide. At each operation and each dressing of the wound, this drug was applied locally in the form of a powder or crystals. After the wound had been closed by suture, administration of the drug was continued by mouth. In 19 cases wounds were treated; in 16 cases they were war wounds. In 1 the lesion was due to fracture of the tibia which had occurred three years previously, in 1 it followed a fracture of the pelvis; in last case the wounds were due to osteomyelitis.

583. Lenormant, C.: Sulphonamides in Treatment of Traumatic Osteitis with Fistulae, *Bull. War Surg.* 3:265 (Jan.) 1943.

of the humerus, radius and ulna in a child of 6 years. Most of the lesions showed profuse suppuration and sequestration. With this treatment the results of operation were much improved. Postoperatively suppuration was slight or absent and there was no important febrile reaction. Granulation tissue appeared more healthy. All but 1 wound were completely healed on the patient's discharge from the hospital, one to two and a half months after operation. Eleven patients were followed for five to eight months, and there were no recurrences. Sulfonamide compounds do not promote ossification of fractures bridged by fibrous tissue, but they do permit further operation to produce bony union even in the presence of primary infection. In 3 cases a small infected cavity was opened in the bone, cleaned out and powdered with sulfonamide drugs and the wound closed by primary suture. The results were good. [ED. NOTE.—This is a good article, but the follow-up period is entirely too brief for conclusions to be drawn.]

In 2 cases Lenormant and Calvet<sup>584</sup> treated chronic staphylococcic abscess of bone by evacuation of pus, local application of a sulfonamide drug and primary suture. Fistulas developed in both cases, and the wounds had to be reopened. In 3 other cases the infection responded moderately well to operation, local application of a sulfonamide drug and drainage of the site together with administration of a sulfonamide compound by mouth. The results were definitely less favorable than those in streptococcic infections. Lenormant then tried simultaneous administration of large doses of an iodide preparation and sulfonamide drug. In anthrax the results were good; cure was rapid without surgical intervention. Calvet treated 8 children with acute osteomyelitis with an iodide solution and sulfanilamide given by mouth. Only puncture and incision of the abscess were done. The response was dramatic, with relief of pain and pyrexia in two to eight days. The course of healing was followed by roentgenographic study, all but 1 patient being followed for from five to nine months. All remained cured. This treatment should be started as early as possible, before suppuration and necrosis have invaded the bony tissue. It was not considered sufficient for subacute osteomyelitis with pyemia. [ED. NOTE.—Good results with the proper use of sulfonamide drugs are now common experience. The advantage of giving iodides is open to question.]

Angevine<sup>585</sup> observes that sulfanilamide, sulfathiazole, sulfadiazine and sulfapyridine can be suspended in oil in high concentrations. Suspensions of sulfanilamide and of sulfathiazole in soybean oil produced only a slight local reaction when injected subcutaneously into experimental animals.

A single subcutaneous injection was absorbed at a uniform rate and produced a concentration of the drug in the blood for as long as eight days, depending on the dose. Excretion of the drug in the urine continued for several days after it had disappeared from the blood. Suspensions of sulfanilamide or sulfathiazole in soybean oil were instilled into the infected sinus tracts of 5 patients with osteomyelitis. The drug was present in their blood for six days and was excreted for as long as one hundred and thirty-seven days. The sinuses of 2 of these patients are entirely healed, and the others are improved. The author feels that this therapeutic method deserves further trial in chronic osteomyelitis and in other wounds. [ED. NOTE.—It is to be hoped that further work along this line may be done.]

For the past four years, Lewis and Senter<sup>586</sup> have used sulfonamide drugs as an adjunct in the treatment of acute and chronic osteomyelitis. Sulfathiazole was used most frequently and was used locally and orally. After saucerization and curettement, the wound was packed with 4 to 8 Gm. of the drug and petrolatum gauze. In cases in which the infection was acute, the administration of large doses of sulfathiazole was begun on diagnosis and continued postoperatively until the acute infection had subsided. The dose was 6 Gm. daily for adults and 0.09 to 0.13 Gm. (1.5 to 2 grains) per pound of body weight (0.045 to 0.065 Gm. per kilogram) for children. In cases in which the infection was chronic, 3 to 4 Gm. given by mouth daily for adults and 0.06 to 0.09 Gm. (1 to 1.5 grains) per pound of body weight (0.03 to 0.045 Gm. per kilogram) for children were advised for a few days following operation. Early active motion is used after a preliminary postoperative period of immobilization. The authors review 307 cases observed from 1925 to 1942. They conclude that sulfonamide drugs are of definite value with surgical treatment in acute osteomyelitis. They are of little value for chronic infections except in has-

585. Angevine, D. M.: Absorption and Excretion of Sulfonamide Compounds Suspended in Oil: Observations on Animals and on Patients with Chronic Osteomyelitis, *War Med.* 3:185-193 (Feb.) 1943.

586. Lewis, J. R. Jr., and Senter, W. J.: Osteomyelitis, *J. M. A. Georgia* 32:302-306 (Sept.) 1943.

584. Lenormant, C., and Calvet, J.: Sulphonamides Treatment of Staphylococcal Osteitis, *Bull. War Med.* 3:265 (Jan.) 1943.

tening remission of acute exacerbations and in preventing exacerbations following operation.

A number of patients with osteomyelitis were treated conservatively by James,<sup>587</sup> with good results. Treatment consisted of rest, application of heat and administration of sulfathiazole. For toxic conditions blood transfusions are of value. Early control of the bacteremia limits the development of foci. Abscesses may disappear without being opened, and secondary infection may thus be avoided. Sequestrums are rendered aseptic and are absorbed or reconstituted into healthy bone. Convalescence is shortened, and no deformities or scars result. The author feels that plaster casts should not be used in this disease. [ED. NOTE.—This is a rather overoptimistic report on a disease that is notoriously difficult.]

Pascau Perez<sup>588</sup> reviews 300 cases of hematogenous osteomyelitis and presents analytic data on the site of involvement: The lower extremity was involved in 81 per cent of the cases, the upper extremity in 17.34 per cent and the trunk in 1.66 per cent. The tibia was involved in 122 cases, the femur in 88 and the humerus in 29. In 110 cases there was a history of definite trauma; this preceded the first symptoms by from three to twenty-four days. In 25 of the cases in which there was a history of trauma the patients were convalescing from various infectious diseases. The hypertoxic form occurred in 2.66 per cent of the cases, the acute form in 43 per cent, the chronic form in 48.66 per cent, the sclerosing type of Garré in 3 per cent and Brodie's abscess in 2.66 per cent. In 65 of the 129 cases of acute infection the patients were treated with simple incision of the subperiosteal abscess and immobilization. Slowly developing osteomyelitis was treated with sulfanilamide, incision and immobilization by means of holes drilled in the metaphysis. For serious involvement of bone the treatment consisted of ample opening, grooving the bone, removing sequestrums, packing the cavity with petrolatum gauze and immobilization. Cure was obtained in 245 of the 300 cases, or 81.66 per cent; in 43 cases the final result was not yet established. Amputation was necessary in 8 cases, and in 4, or 1.3 per cent, the patients died. Of the 245 cases in which cure was effected,

there was no deformity or restriction of function in 29.66 per cent. In 42 per cent there was thickening of bone; in 10 per cent there was evident thickening, some shortening and limitation of function; in a few some degree of ankylosis was present. Three of the patients whom amputation was performed had had osteomyelitis for more than thirty years. In 1 case malignant growth sprang from the osteomyelitic focus. [ED. NOTE.—The large series and analytic data presented in this article make it important.]

Dennis<sup>589</sup> notes that with the Orr method with expectant treatment for chronic osteomyelitis 25 per cent of the patients showed healing with cessation of drainage. Many patients returned with exacerbations months and years after apparent healing. Roentgenograms showed areas of rarefaction, which were suggestive of absorption of bone, and areas of irregularity and sclerosis. These pictures imply quiescence and not a return to normal structure and function. Treatment by prolonged dependent drainage with rigid tubes was instituted in 12 cases. Various materials were tried experimentally, and Lucite (polymerized methyl methacrylate) was found to be least irritating. It softens in boiling water and can be molded. The tubes were 7 mm. internal diameter, and they were sterilized in an aqueous solution of metaphen. The tibia is the best site for placement of the drains. The abscess cavity is opened and packed with dry gauze which is removed after a few days. An ante-cubital hole to accommodate the drain is drilled 10 cm. below into the cavity. This permits drainage when the patient is erect. Another is drilled from the posterior aspect at right angles to the skin to allow drainage when the patient is supine. The tubes are held in place by wire. A cast is applied; two weeks later this is removed, and the patient is allowed full activity. Daily irrigations with buffered aqueous solution of sodium hypochlorite are used. Six of the patients were reported cured in two to eighteen months, 4 were still under treatment after six to twelve months and there were two failures. One failure occurred in an obese patient with osteomyelitis of the humerus in whom drains could not be held in place. The other occurred in a patient with osteomyelitis of the femur with extensive necrosis; after placement of the drains, there was relief of discomfort and ache, and no ill effects.

587. James, E. S.: Conservative Treatment of Acute Osteomyelitis. *Manitoba M. Rev.* 23:314-315 (Dec.) 1943.

588. Pascau Perez, L.: Therapy of Hematogenous Osteomyelitis: Critical Study Based on Three Hundred Cases. *Cir. ortop. y traumatol., Habana* 10:81-110 (April-June) 1942.

589. Dennis, C.: Prolonged Dependent Drainage with "Lucite" Drains in Treatment of Chronic Osteomyelitis. *Surgery* 13:900-910 (June) 1943.

s noted when normal activity was permitted. Miley feels that this method of therapy is best adapted to superficial long bones, where saucerization, application of sulfathiazole and primary closure are most difficult because of inadequate tissue for obliteration of the dead space. The author also believes that prolonged dependent drainage best restores normal bony architecture, as shown by roentgenograms.

Miley<sup>590</sup> reports a case of hemolytic *Staph. aureus* septicemia in which rather striking results followed ultraviolet blood irradiation, with the Knott technic. In brief, this consists in withdrawing a certain amount of the patient's blood, exposing it to high intensity ultraviolet rays and immediately reinjecting it into the patient. The author mentions that he previously reported on patients who received no benefit from this therapy but that he feels that this case shows what can be accomplished by the Knott technic. He also expresses the opinion that therapy should be instituted early and whole blood transfusions used as needed but warns against the use of any sulfonamide drugs if ultraviolet irradiation of the blood is employed. [ED. NOTE.—I feel that this method has little to recommend it in comparison with the excellent results obtained today with the use of penicillin.]

In connection with the surgical treatment of osteomyelitis due to a penetrating wound, Perkins<sup>591</sup> takes the opportunity of illustrating the sequelae of a compound fracture. He cites these as follows: The inflammation may subside, acute osteomyelitis may develop, a sinus may develop, the wound may stay quiescent for years but ultimately flare up. In short, he states that there is no surgical treatment for persistent acute inflammation of the bone and makes the amazing statement that "in persistent acute osteomyelitis amputation of the limb is therefore often advisable, either to save life or because an artificial limb will be of more use to the patient than his own crippled leg." If persistent osteomyelitis is caused by loose bone or a foreign body, its removal may permit closure of the wound. Roentgenographic evidence here is of great help but is not decisive. He states that exacerbations are the most difficult to treat and that treatment should

consist of rest and hot applications to the part. No surgical operation is recommended unless an abscess forms; when this occurs the abscess should simply be opened. [ED. NOTE.—Amputation has little place in the treatment of acute osteomyelitis. Unnecessary surgical treatment jeopardizes the patient's life. In the acute stage it is impossible to evaluate the final status of the extremity.]

Wilkinson<sup>592</sup> reports on 40 patients with acute hematogenous osteomyelitis due to staphylococci who were treated in 1940 and 1941. On admission to the hospital the patient is put to bed and given sedatives, fluids, dextrose or saline solution intravenously if necessary and transfusions if necessary. One and one-half to 2 grains (0.09 to 0.13 Gm.) of sulfathiazole per pound of body weight (0.045 to 0.065 Gm. per kilogram) is given daily. The first dose, given on admission, is one half of the calculated daily dose. If oral administration is impossible, sodium sulfathiazole is given intravenously in the same dose. Surgical intervention is contraindicated until measures have been taken to combat septicemia. When there is reasonable certainty that pus is present, operation is done if the general condition is satisfactory and the blood sulfathiazole level is 5 mg. per hundred cubic centimeters or more. These conditions are usually fulfilled within twenty-four hours. Incision over the affected bone, with the patient under general anesthesia and without a tourniquet, was advised, with division of the periosteum, evacuation of pus and the making of two drill holes into the metaphysis. The author packs the wound loosely with gauze soaked in acriflavine in glycerin or some other greasy material, applies a dressing and places the extremity in plaster or traction. The packing is removed at the end of a month and not replaced. The dose of sulfathiazole was cut at the end of the first week and continued for at least four weeks. The author reported 2 deaths; in 8 of the 38 surviving patients the wounds failed to heal.

Wilson and McKeever<sup>593</sup> report on 31 patients with acute osteomyelitis, of whom 20 were boys and 11 girls. None was over 13 years of age. All of the patients were febrile, toxic and dehydrated, and for all the initial roentgenograms revealed no abnormality. In 30 of the patients

590. Miley, G.: Disappearance of Hemolytic *Staphylococcus Aureus* Septicemia Following Ultraviolet Blood Irradiation Therapy: Knott Technic, *Am. J. Surg.* **62**: 41-245 (Nov.) 1943.

591. Perkins, G.: Surgical Treatment of Osteomyelitis Due to Penetrating Wound, *Brit. M. J.* **1**:441-442 (April 10) 1943.

592. Wilkinson, F. R.: Treatment of Osteomyelitis, *Tr. Roy. Med.-Chir. Soc. Glasgow*, 1942-1943, pp. 2-5; in *Glasgow M. J.*, December 1942.

593. Wilson, J. C., and McKeever, F. M.: Role of Sulfonamide Drugs in Treatment of Hematogenous Osteomyelitis, *J. Bone & Joint Surg.* **25**:41-48 (Jan.) 1943.

the onset had occurred five to seven days before admission to the hospital. In 28 of the patients the infection was caused by *Staph. aureus haemolyticus*, and in 20 of these the organism was recovered from the blood stream. Sulfathiazole was used; in 21 patients an average dose of 4.6 Gm. was given for eleven and seven-tenths days. For 6 patients, sulfapyridine was used for ten days. Sulfanilamide was used for 2, and several received both sulfanilamide and sulfapyridine. Blood transfusions were employed when indicated. In 27 of the patients, all of whom had abscesses, the drug therapy was supplemented by surgical operation. Twenty-three had conservative surgical operation directed at both the soft tissues and the bone; on 4 the operation involved the soft tissues only. The patients showed rapid improvement; 16 of the 20 patients whose blood culture was positive had a culture a week later which was negative. The effect of the drug on the fever was inconstant; in about one half of the patients studied, the temperature did not reach and maintain a normal level until the abscess had been drained. Erythema nodosum developed in 3 patients and jaundice in 1. There was 1 death, giving a mortality of 3.2 per cent, while in the same hospital prior to the use of sulfonamide drugs the mortality had been 12.7 per cent. In 20 of the patients who were examined some months later all the sinuses were healed. There was good reconstruction of the affected bone, with no evidence of central abscess and no impairment of function of joints.

Wilensky<sup>594</sup> points out that the treatment of acute hematogenous osteomyelitis is concerned with three factors: (1) the general infection, (2) the lesion of the bone and (3) the presence of other metastatic lesions. At an early period in the development of the focus in the bone, the bacteremia is due to a primary lesion elsewhere; this is confirmed by the spontaneous disappearance of the bacteremia within a few days. At a later period both the primary lesion and the osseous lesion may be responsible for a positive blood culture. When progressive diminution in the number of colonies ceases and a few colonies persist in spite of chemotherapy, the probable cause is thrombophlebitis in or about the focus in the bone. Traumatization of the focus, such as operation or manipulation, may cause bacteremia. Treatment of the various degrees of infection may be grouped as follows: 1. For mild infec-

tion with slight clinical symptoms and blood cultures which yield ten to thirty colonies per cubic centimeter, the drug selected should be given in a dosage commensurate with the degree of infection. If the blood culture does not become sterile within a short time, the assumption that there is active thrombophlebitis in the focus. If excision of the focus is impossible, ligation of the main vein draining the involved part may be considered. 2. Severe infection (one hundred or more colonies per cubic centimeter) requires intensive chemotherapy. Here, again, if bacteremia persists one should consider ligation. The most severe infection (innumerable colonies per cubic centimeter) is overwhelming and presumably involves multiple organs; the only possible treatment is chemotherapy. It is stressed that in the early stages, while bacteremia is present, treatment should be conservative, including chemotherapy and transfusions. Three conditions may follow formation of a focus of osteomyelitis: (1) spontaneous resolution, (2) formation of an abscess under the periosteum of the bone, which may spread to the soft parts, and (3) bony necrosis and sequestration. When there is no generalized infection, operation should be limited to incision and drainage of abscesses only. The pathologic process should be permitted to develop, to retrogress spontaneously or to go on to the stage of necrosis and sequestration uninfluenced by surgical intervention.

Eggers and Knight<sup>595</sup> discuss the treatment of osteomyelitis under the following heads: (1) for traumatic acute infection, complete débridement, irrigation, local application of sulfonamide drugs, primary closure over the bony defect and adequate immobilization; (2) for infected traumatic acute osteomyelitis, adequate surgical drainage, removal of necrotic tissue and either local application of sulfonamide compounds or the Orr treatment; (3) for acute hematic infection, general supportive measures, including systemic administration of sulfonamide drugs and transfusions, drilling of bone and local application of sulfonamide compounds, and later sequestrectomy and saucerization followed by local application of sulfonamide drugs or the Orr treatment; (4) for chronic hematic osteomyelitis, saucerization where indicated followed by local application of sulfonamide drugs or the Orr method; (5) after active infection of bone subsides, etc.

594. Wilensky, A. O.: *Modern Treatment of Acute Hematogenous Osteomyelitis of Long Bones*, Connecticut M. J. 7:26-29 (Jan.) 1943.

595. Eggers, G. W. N., and Knight, M. D.: *Treatment of Osteomyelitis*, Texas State J. Med. 39:257-267 (Sept.) 1943.

grafting by the sliding, split graft or the pedicle full thickness technic. The authors conclude that for chronic infection local treatment with sulfonamide drugs is as effective as a combination of local and systemic therapy. They found the results of the Orr method and those of treatment with sulfonamide drugs about the same but preferred the latter. Of 366 patients about 83 per cent were well for at least three years. [Ed. NOTE.—I should consider 83 a good percentage.]

McKeown<sup>596</sup> reviews 100 cases of acute osteomyelitis and emphasizes the 26 in which sulfathiazole was used. He gave the drug in a dosage of 1 Gm. per 20 pounds (9 Kg.) of body weight per day for eight days and repeated this after an interval of three weeks. In 17 cases also the metaphysis was drilled by the sixth day and a cast applied. In 9 cases varied treatment with minimal surgical treatment was given. The best results were obtained with sulfathiazole treatment. The author concluded that sulfathiazole is most beneficial for early acute osteomyelitis, in a dosage calculated to produce a blood level of not over 6 mg. per hundred cubic centimeters. There is some evidence that albuminuria occurs less often when the urine is acid and can be avoided by giving 100 mg. of nicotinic acid daily with higher doses of sulfathiazole. Drilling of bone gave better results than any other surgical procedure and was most effective when done early in the disease and when combined with an adequate dose of sulfathiazole. No definite permanent improvement was obtained from the use of sulfathiazole in chronic osteomyelitis. Sulfathiazole seemed to reduce the duration of the disease.

Robertson<sup>597</sup> reports 89 cases of osteomyelitis, 90 per cent of which staphylococci were the cause; the treatment consisted of administration of large doses of sulfonamide drugs. The average dose for an 8 year old child was 8 to 10 Gm. daily, which produced a blood level of 6 to 12 mg. per hundred cubic centimeters. He noted great individual variation in the blood level with large doses. In about 8 per cent of the cases reactions required discontinuance of the drug or changing from sulfathiazole to sulfadiazine. The author advises high initial doses. Sulfonamide drugs do not inhibit the formation of antitoxin. No surgical operation was done in about 30 per cent of the cases of this series; in the 1 case in which

incision was resorted to early death resulted. Sequestration occurred in only 10 to 15 per cent of the cases. Traction was the only form of immobilization used, and that was used only when a joint also was involved. The mortality rate was 4.2 per cent. [Ed. NOTE.—No information is given as to when administration of sulfonamide drugs was started in relation to the onset of the disease. The author states that incisional interference is not a factor in saving lives, but its use for late abscesses in about 70 per cent of his cases indicates its value in improving local lesions.]

Alexandrov<sup>598</sup> describes the treatment for chronic osteomyelitis after gunshot injuries. The article is based on a study of 858 cases in the Soviet Union. Auxiliary treatment includes balneotherapy, physical therapy, climatotherapy and the use of diets, vitamins, physical culture and medicine. The most important balneologic factors include various muds, clays and sulfide baths. The chief climatic agent is sunlight. The action of resin, radon, carbon dioxide and thermal baths as well as of naphthalene and koumiss is being investigated. The author thinks that spa treatments should be used also in hospitals. Indications and contraindications for the various treatments are discussed. Often spa treatment needs to be continued for forty-five to sixty days. A table shows the results obtained by various Russian physicians who use spa treatment. [Ed. NOTE.—This interesting method is based on a large number of cases; a report on the roentgenographic changes following the spa treatment would be of value.]

Toumey<sup>599</sup> reports that at the Lahey Clinic 13 patients who had either chronic osteomyelitis with formation of a sinus or acute reactivation of previous osteomyelitis were treated with sulfathiazole and rest in bed for one week before operation, 90 grains (5.8 Gm.) of the drug being given every twenty-four hours. The operation consisted of saucerization, putting 2 to 15 Gm. of sulfathiazole in the wound, closure without drainage and plaster immobilization. Sulfathiazole was given orally for at least two weeks post-operatively. No saucerization was done in cases of actively draining sinuses without extensive infection of bone. All wounds healed promptly except 2 in patients who did not tolerate sulfathiazole. Sulfathiazole therapy without operation was ineffective.

<sup>596</sup> McKeown, K. C.: Role of Chemotherapy in Treatment of Haematogenous Osteomyelitis, *Brit. J. Surg.* 31:13-22 (July) 1943.

<sup>597</sup> Robertson, D. E.: Medical Treatment of Haematogenous Osteomyelitis, *Ann. Surg.* 118:318-328 (Aug.) 1943.

<sup>598</sup> Alexandrov, V. A.: Spa Treatment of Chronic Osteomyelitis After Gunshot Injuries of Bone, *Brit. J. Phys. Med.* 6:130-132 (Sept.-Oct.) 1943.

<sup>599</sup> Toumey, J. W.: Sulfathiazole in Chronic Osteomyelitis, *Surgery* 14:531-540 (Oct.) 1943.



In the treatment of compound fractures infected with *Staph. pyogenes*, Heggie and Kendall<sup>600</sup> prefer sulfathiazole to sulfadiazine because it is ten times as bacteriostatic and is better tolerated. Four cases are described to show that chemotherapy before and after operation is essential and should be supplemented by local application at the time of surgical treatment. Sulfathiazole applied locally proves ineffective unless supported by oral administration, and even slight or moderate infection requires repeated application. No staphylococci were found to be resistant to sulfonamide drugs.

Truog<sup>601</sup> points out that a definite roentgenologic diagnosis of lesions of bone due to acquired syphilis is difficult because of their varied manifestations. Believing that all syphilitic lesions of bone should be termed syphilitic osteomyelitis, the author presents 9 cases with eight roentgenograms to show the osteomyelitic nature of acquired syphilis of bone. A correct diagnosis can be made if differential roentgenographic criteria are studied carefully.

Kleiger and Blair<sup>602</sup> feel that some strains of staphylococci produce a potent exotoxin which when injected intravenously into laboratory animals causes convulsions and death; toxigenic staphylococci when injected intravenously into laboratory animals are capable of producing the exotoxin and causing death. Susceptible patients who are infected by toxigenic staphylococci suffer from abdominal pain, diarrhea, incontinence, meningismus, coma and delirium with a rapid rise in pulse rate and temperature. In such cases a potent specific antitoxin has proved effective, its dosage being adjusted to the size of the patient and to the degree of toxicity. Between 1,000 and 2,000 units of antitoxin per pound of body weight (between 2,200 and 4,400 units per kilogram) is given on the first day, with smaller doses thereafter. It is emphasized that the antitoxin is effective only in true staphylococcic toxemia in young patients. The authors describe a routine for minimizing serum reactions.

McClean, Rogers, Williams and Hale studying gas infections in laboratory animals sought to determine how early bacterial enzymes can be detected in edema fluid or exudate from a wound. If the strain was capable of producing hyaluronidase, the enzyme could be detected in the edema fluid as soon as enough fluid could be obtained for examination and in muscle the earliest sign of infection. Lecithinase was detected at a similar stage in *Cl. welchii* infection. Most strains of *Cl. welchii* associated with gangrene and all strains of *Clostridium septicum* produced hyaluronidase, but less than half the strains of *Clostridium oedematiens* produced it. The authors describe methods for the detection of hyaluronidase and lecithinase. Emphasis is placed on the fact that these experiments were made with pure cultures whereas infections in wounds are usually mixed.

L'Episcopo and Hagerty<sup>604</sup> present a series of 27 patients with acute hematogenous osteomyelitis who were treated by rest in bed, trauma, massive hot wet packs, correction of dehydration, multiple blood transfusions, oral administration of sulfonamide drugs and aspirations. Four patients required delayed incision and drainage of the soft tissues; in 5 others sinuses developed while 18 had no scars, sinuses, operations, deformity or disability of any kind. Sulfanilamide was used for streptococcal infections and sulfathiazole for staphylococcal infections. The authors consider this treatment adequate except in cases in which a joint is threatened or in which aspirations do not control the abscess.

Solomon and Bachman<sup>605</sup> show that in pyogenic osteomyelitis of the spine the lesions often remain unrecognized because respiratory symptoms mask the spinal symptoms. Roentgenograms show one of the early signs to be narrowing of the intervertebral space due to destruction of the disk. Any patient who has a fever, temperature, rigidity and fixation of the muscles of the back, pain over the spine and roentgenographic evidence of mediastinitis must be suspected of having osteomyelitis of the spine. The authors present an illustrative case.

600. Heggie, J. F.; Kendall, A. W., and Heggie, R. M.: Infected Wounds Involving Bone Treated with Sulphapyridine and Sulphathiazole, *Brit. M. J.* **2**:655-658 (Dec. 5) 1942.

601. Truog, C. P.: Bone Lesions in Acquired Syphilis, *Radiology* **40**:1-9 (Jan.) 1943.

602. Kleiger, B., and Blair, J. E.: Role of Toxin and Use of Antitoxin in Systemic Staphylococcal Infections, *Arch. Surg.* **46**:548-554 (April) 1943.

603. McClean, D.; Rogers, H. J.; Williams, B., and Hale, C. W.: Early Diagnosis of Wound Infection with Special Reference to Gas Gangrene, *Lancet* **355**:360 (March 20) 1943.

604. L'Episcopo, J. B., and Hagerty, E. D.: Conservative Management of Acute Osteomyelitis, *York State J. Med.* **43**:853-856 (May 1) 1943.

605. Solomon, H. A., and Bachman, A. L.: Pyogenic Osteomyelitis of Thoracic Spine Presenting as Primary Pulmonary Disease, *Am. J. Roentgenol.* **219**:226 (Feb.) 1943.

## A REVIEW OF UROLOGIC SURGERY

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### URETER

*Anomalies.*—Andrews and Vernon<sup>30</sup> state that ectopic ureter usually occurs in females. In women this anomaly leads to incontinence of part of the urine and normal vesical control of the remainder. In men the opening of the aberrant ureter is above the external sphincter and incontinence of urine does not occur. The most common site of an opening of an ectopic ureter in the female is in the vestibule near the external meatus. This is readily understandable when it is remembered that this structure, like the ureter, develops from the wolffian ducts. The vagina develops from the müllerian ducts, and a true ectopic vaginal ureter is rare. The vaginal opening of an ectopic ureter is nearly always situated on the anterior wall near the midline, but when the opening is near the cervix it tends to become more lateral. Only 5 cases in which an ectopic ureter opened near the cervix in the lateral fornix have been found. After an exhaustive search of the literature.

Andrews and Vernon report a case in which a girl, aged 12 years, had incontinence of urine but passed urine naturally and appeared to have vesical control. Cystoscopy revealed two ureteral orifices in the bladder and also an outlet in the vagina. Intravenous pyelograms showed that the kidneys were apparently normal. There

also was evidence of a double ureter and an accessory calix above the left kidney. Operation revealed a double kidney. The small accessory pelvis and a portion of the ureter were removed.

*Tumor.*—Rademaker<sup>31</sup> reports a case of leiomyosarcoma of the ureter. This represents the sixth case of primary sarcoma of the ureter that has been reported in the literature. The chief features of the growth were: It produced relatively few symptoms, there were no obvious metastatic lesions, although the tumor was large, the tumor was well encapsulated and the index of malignancy was low. The difficulties in diagnosis are obvious because of the negative results of laboratory and roentgenologic studies. Removal of the tumor was complicated by violent hemorrhage. Convalescence after operation was uneventful. It is yet too early to discuss the final end result.

McMahon<sup>32</sup> reports 2 cases of tumor of the ureter. In the first case the patient had a simple tumor of the ureter; the site and limit of the tumor were well demonstrated by a ureterogram. In the second case the patient had a bilharzial tumor of the ureter, which was demonstrated by ureterography. It is now being recognized that

31. Rademaker, L.: Primary Sarcoma of the Ureter: Case Report and Review of the Literature, *Am. J. Surg.* 62:402-406 (Dec.) 1943.

32. McMahon, S.: Tumors of the Ureter, *J. Urol.* 51:616-622 (June) 1944.

30. Andrews, J. A., and Vernon, H. K.: Ectopic Vaginal Ureter, *Brit. J. Surg.* 31:195-197 (Oct.) 1943.

bilharziasis is a serious disease. Unfortunately, in the initial stage of the disease, when hematuria is present and ova are found in the urine, the symptoms are mild and the disease often is neglected. In this stage treatment with antimony is indicated. If the disease is neglected or if insufficient treatment is given, sequelae related to the ureters are common. The most frequent ureteral complication is stricture of the intramural portion of the ureter and dilatation of the pelvic portion. Formation of a tumor is rare.

Counsellor, Cook and Seefeld<sup>33</sup> consider primary epithelioma of the ureter and report 9 new cases and the results of a follow-up study of 18 cases previously reported.

Their follow-up study revealed that, regardless of the type of operation employed, 7 of 10 patients who had lesions graded 1 or 2 lived more than four years after operation and 1 of these lived more than thirteen years. Of the 8 patients who had lesions graded 3 or 4, 6 died within two and one-half years, excluding 1 patient who died after the operation. The remaining patient, who had a growth with a high grade of malignancy, lived more than twelve years, at the time the paper was written there were indications of probable recurrence of the lesion of the bladder. In the light of these findings, it must be stressed that in cases of low grade ureteral carcinoma—and in the majority of cases the grade of malignancy is low—early diagnosis is of the utmost importance, because there should be a chance for moderately long survival if adequate treatment is undertaken at once.

The tendency of epithelioma of the ureter to recur in the bladder has been pointed out, and this feature was emphasized as the follow-up studies became of longer duration. A tumor of the bladder may follow a ureteral neoplasm with no apparent relation to the method of treating the tumor in the ureter.

The possibility of growth of these tumors by lymphatic extension or by direct extension down the ureter and through its walls to contiguous structures is mentioned, and it is brought out that complete extirpation of the kidney, ureter, all periureteric adipose tissue and the ureterovesical segment of the bladder is the procedure of choice.

In the 9 new cases a diagnosis of primary ureteral neoplasm was proved after examination of the pelvis. In 1 case the kidney was not re-

moved because of extensive bilateral pulmonary tuberculosis, which made the patient an extremely poor surgical risk. In this case the tumor was situated at the right ureterovesical junction in the intramural portion of the ureter, and transurethral electrocoagulation was considered to be the only feasible therapeutic procedure to be followed under the circumstances. However, retrograde pyelography subsequently revealed renal pelvis to have a normal outline.

In the 9 new cases, 6 of the patients were men and 3 were women. The average age was 64 years; all of the patients were 57 to 71 years of age inclusive.

All of the tumors were graded according to the classification of Broders for vesical tumors: 4 were grade 1, 4 were grade 2 and 2 were grade 4. Of the 9 tumors, 6 were papillary and 3 were infiltrating of which 1 was grade 2 and 2 were grade 4.

Five of the tumors occurred in the right ureter and 4 occurred in the left. One lesion was situated in the upper third of the ureter, 1 in the middle third and the rest all occupied the lower third, as has been found in more than two thirds of the cases reported in the literature. In 2 cases mild or severe periureteritis was present.

Dilatation of the ureter and hydronephrosis were prominent features in all 9 cases. Destruction of renal substance was as high as 90 per cent in 1 case and 80 per cent in another. In 2 cases a palpable mass was present at the first examination. In 4 cases secondary infection accompanied by pyonephritis was present. Calculi were not observed as an accompanying feature in any case.

Hematuria and pain were the primary symptoms, and a mass in the loin also occurred frequently. Hematuria was present in 8 of the 9 cases. It was the first symptom in 4 cases and the only symptom in 2 cases. Hematuria was gross in 4 cases and microscopic in 4. Pain was present in 6 cases. It was the first symptom in 3 cases and varied from a dull aching in the loin or lower quadrant to typical renal and ureteral colic, associated with chills and fever.

Cystoscopic examination was of real value in the diagnosis of these ureteral neoplasms. In 3 of the 9 cases, the tumor protruded from the ureteral orifice and biopsy was facilitated. In 1 case, a large tumor surrounded the ureteral orifice. This appeared at first to be attached to the left anterior wall of the bladder and left vesicoprostatic juncture, but when the tumor was removed from the region of the ureteral meatus it became apparent that it protruded from the

33. Counsellor, V. S.; Cook, E. N., and Seefeld, P. H.: Primary Epithelioma of the Ureter: A Follow-Up Study of Eighteen Cases with the Addition of Nine New Cases, *J. Urol.* 51:606-615 (June) 1944.

ureter. In 5 cases, no evidence of tumor was found on cystoscopic examination. In all cases, however, passage of a ureteral catheter met with obstruction at the site of the tumor, and in the majority of instances catheterization of the involved ureter was accompanied by bleeding, which tended to be moderately profuse. Blood spurting from the ureteral orifice was seen even before instrumentation was attempted in 1 case.

Excretory urography was of no aid in actually demonstrating the presence or position of the lesion in any of these 9 cases but was helpful in revealing the degree of renal function present. In the majority of cases, renal function was diminished to such a degree that the amount of dilatation of the urinary tract above the lesion was not shown.

The presence and position of the lesion itself were best seen in retrograde pyeloureterograms. Ureterectasis, incomplete filling, complete obstruction to the medium and a filling defect were all observed in these cases. A more accurate and exact evaluation of the underlying obstruction process was possible than if pyeloureterography had not been done.

With the aid of these diagnostic methods, it was possible to reach a correct preoperative diagnosis in all the cases under discussion.

**Stone.**—Browne<sup>34</sup> discusses his experiences with ureteral calculi, based on a series of 200 cases. Except for acute retention of urine, there is nothing that will make a patient seek a doctor quicker than ureteral colic. Erythrocytes usually are found in the urine, and there is generally no fever. One is impressed with the gastrointestinal symptoms, chiefly nausea and vomiting, that accompany ureteral colic. As the stone moves lower in the ureter, urinary frequency and burning on urination increase. When infection is present and the ureter is blocked by the stone, there may be high temperature and severe prostration.

Many stones will pass unaided. This occurred in 17 cases. No stone situated in the upper and middle portions of the ureter passed spontaneously. Browne has not had much success with injecting oil or anesthetics above the stone or giving drugs by mouth to aid the passage of calculi.

In 141, or 70 per cent, of the cases the calculi were removed with the cystoscope. The simple passage of a catheter by the stone caused its prompt delivery in the majority of cases. If this did not prove successful, one or more catheters were passed up to the kidney and left there for

two or more days. Usually, after this the stone was passed in twenty-four hours or crumbled from the hard catheter lying against it. Irrigation has been advocated to keep the catheter open, but Browne expresses the opinion that this is to be condemned because of the danger of introducing infection into the kidney. If the catheter becomes plugged, the urine will escape around it anyway. Sulfathiazole was given continuously to prevent infection, which causes the most trouble. Some stones impacted in the wall of the bladder have been removed by enlarging the ureteral orifice with a Turner electrode, then passing a metal bougie by the stone, thus engaging and removing it. Browne does not use this instrument any more for fear of tearing the ureteral wall. He has tried the Councill extractor but found that it is too rigid to be passed any distance up the ureter without danger of injury.

In 34 cases the calculi were removed by operation. In 12 of the 34 cases the calculi were in the upper part of the ureter; in 5 cases they were in the middle third, and in 17 cases they were in the lower third of the ureter. He uses a lateral incision, parallel to Poupart's ligament, in removing calculi from the lower part of the ureter, because the ureter can be found easily above the bifurcation of the common iliac artery. From this point the ureter is readily followed until the stone is felt, and if the ureter is very deep in the pelvis, the incision can be extended to and through the sheath of the rectus muscle, thus giving ample exposure. If necessary, the bladder can be opened. In 2 cases, vaginal ureterolithotomy was performed. The stones were low and palpable through the vaginal wall.

Browne is using manipulation less frequently and is operating more frequently in cases of ureteral calculi. If after three trials with the cystoscope the stone fails to pass and shows evidence of impaction, he operates. If there are no symptoms, if there is no infection and if the stone is small, the patient is kept under observation and often in time the stone will pass.

**Stricture.**—Fergusson<sup>35</sup> reports a case in which perirenal urinary extravasation occurred on the right side as the result of obstruction of the lower part of the ureter by carcinomatous lymph nodes. The patient was a man aged 39 years. The primary carcinoma in the stomach was not discovered until necropsy was performed. Reference was made to a few reported cases of metastatic involvement of the ureter by distant

34. Browne, H. S.: Experiences with Ureteral Calculi, *J. Urol.* 50:301-303 (Sept.) 1943.

35. Fergusson, J. D.: Ureteral Stricture with Perirenal Urinary Extravasation, Caused by Metastases from a Silent Carcinoma of the Stomach, *Brit. J. Surg.* 31:283-286 (Jan.) 1944.

neoplasms. The author mentions the difficulties which may be encountered when a malignant lesion is not suspected.

#### BLADDER

*Paralysis.*—Riches<sup>36</sup> discusses the methods and results of treatment of paralysis of the bladder due to spinal injury. He states that after such paralysis occurs the only satisfactory methods of voiding are voluntary micturition, periodic reflex of a lesion on the cauda equina or suprapubic cystotomy.

The main obstacle to the final attainment of a satisfactory act is infection of the urinary tract; other factors which may retard recovery are urinary leakage, which favors development of pressure sores, and prolonged overdistention, which leads to muscular damage and fibrosis. Infection of the urinary tract may cause death or permanent disability. It is introduced by urethral catheterization. Urethral catheterization should be forbidden absolutely unless and until surgical facilities are perfect. The relief of retention is not an urgent matter and is rarely necessary in the first twenty-four hours. Overflow incontinence is a safe solution of the problem of retention but may produce dermatitis of the urinary tract and pressure sores, especially if the patient is a woman.

If retention must be relieved on account of pain, the alternatives which are safer than a urethral catheter are: suprapubic aspiration, suprapubic catheterization and suprapubic cystotomy. Suprapubic catheterization of the distended bladder offers an efficient method of treatment. It can be combined with tidal drainage after two days.

Manual expression is too hazardous and uncertain to be advised for general use.

To be satisfactory for either immediate or permanent treatment, any suprapubic opening must be made high and must be water tight.

Intermittent catheterization should be reserved for mild retention and limited in any event to two days. If there is no recovery after two days the patient should be treated by suprapubic catheterization, with subsequent tidal drainage. Tidal drainage with an indwelling urethral catheter should be used only in a center and by a person who has had special experience with the method. There should be no delay in replacing it by suprapubic catheterization if gross inspection of the urine shows evidence of infection.

36. Riches, E. W.: The Methods and Results of Treatment in Cases of Paralysis of the Bladder Following Spinal Injury, *Brit. J. Surg.* **31**:135-146 (Oct.) 1943.

*Tumor.*—Moore,<sup>37</sup> in discussing carcinoma of the bladder, describes his technic for cystoscopic implantation of radium element. He states it to be suitable for cystoscopic implantation of radium the tumor should be in a situation favorable for a good view and for attack through direct cystoscope; this would include tumors involving the trigone, the lateral bases, posterior wall and the posterior half of the lateral walls. If the growth is in the vesical dome, anterior wall or the anterior half of the lateral walls, this method is unsuitable. He grants that implantation of radium or radon by open operation permits a more accurate placing of the agent and from the surgeon's standpoint is attended by fewer technical difficulties. On the other hand in certain cases cystoscopic implantation of radium is highly desirable, carries less risk and produces fewer complications, a much shorter period of disability and when properly performed gives equally satisfactory results.

In a review of 96 cases of carcinoma of the bladder, Moore found that 11 patients had been treated by implantation of radium element cystoscopically. Seven were women, and 4 were men. For 8 the neoplasm was graded 2, and for 3 it was graded 3. The ages of the patients at the time of treatment varied from 42 to 83 years and averaged 69 years. Six of these patients are living, and 5 have died. Among those surviving are several who have been treated comparatively recently. Of the 5 patients listed as dead, the period of survival after treatment varied from six months to six years and averaged three and three-tenths years. The average age of the patients at death was 77.4 years.

The necessary instruments and equipment for implanting radium cystoscopically are as follows: (1) a special cystoscopic radium implant (Moore), (2) platinum needles containing radium element, 1, 3 or 5 mg., (3) a standard Braasch direct cystoscope and (4) a Foley catheter, 2- or 26 F., with a 75 cc. bag. The radium needles should not be over 10 to 17 mm. in length. Each is threaded with stout silk about 25 cm. in length if the patient is a woman. If the patient is a man, a no. BB lead shot is clamped on the silk thread about 2 cm. from the eye of the needle. One needle for every square centimeter of growth should be prepared.

The jaws of the implanting forceps are grooved longitudinally, permitting the needle to be held firmly and without deflection during its insertion. The end of the forceps is blunt, which insures

37. Moore, T. D.: Carcinoma of the Bladder—Improved Technique for the Cystoscopic Implantation of Radium Element, *J. Urol.* **51**:496-504 (Mar.) 1944.

gainst penetration of the wall of the bladder more deeply than the length of the exposed needle. A direct Braasch cystoscope has been used routinely; an indirect instrument is unsuitable for this purpose. A Foley catheter with a 75 cc. bag is included on the tray; the bag is distended with 120 cc of sterile water, the purpose of which is threefold: to hold the radium at the place of implantation, to keep at a distance the remainder of the vesical wall, in order to protect the patient from radiation cystitis and vesical contracture and to block with the distended bag the vesical outlet and prevent the loss of the radium.

Either low spinal or pentothal sodium anesthesia is usually administered. If the tumor is of a sessile type, electrocoagulation of its entire surface is carried out along with a small margin of surrounding healthy tissue. A radium needle is locked in the implanting forceps, with enough of the needle projecting to reach the deeper portion of the tumor. The end of the cystoscope is placed firmly against the site selected, the ocular is removed and the implant is introduced through the sheath, with the lead shot preceding the needle. When the resistance of the tumor is sensed, the needle is inserted by a short thrust; the implant then is unlocked and withdrawn. The ocular of the cystoscope is replaced; the needle then may be seen, with the thread and lead shot lying free in the bladder. Another site is selected approximately 1.5 cm. from the former, and this procedure is repeated until the required number of needles have been implanted.

For women identifying lead shot can be used, but it is more convenient to use long threads of silk attached to the radium needle, the thread being brought out of the urethra so that the radium can be removed. The cystoscope can be reinserted alongside these threads, and as many as seven radium needles have been implanted in the female bladder in this way. For men this technic is impractical, and the use of identifying lead shot attached closely to the needle is far more satisfactory. The cystoscope is then removed and the 75 cc. Foley catheter inserted. If the capacity of the bladder is not too limited, 120 cc. of sterile water is used to distend the bag.

The patient is returned to his bed, and the catheter is attached to an irrigator by means of a T tube, with an extension tube into a sterile bottle at the bedside. If there is much oozing of blood, a small amount of acriflavine solution (1:5,000) containing sodium citrate (1 per cent) is left in the bladder, and the drainage tube is clamped for one hour. The sodium citrate prevents clotting of blood. The tube is unclamped every hour, and additional irrigating solution is

instilled until the drainage is clear or only pink. In this way, troublesome obstruction of the catheter with clots is avoided.

Depending on the amount of radiation desired, the needles are left in place as long as necessary, usually from forty-eight to seventy-two hours. A direct cystoscope is then reinserted, usually with the patient under pentothal sodium anesthesia; the lead shots are picked up with the cystoscopic forceps and the radium removed. In women, the Foley catheter is removed and the radium is removed by traction on the silk threads.

Herger and Sauer<sup>38</sup> consider the factors which influence success or failure of external radiation in the treatment of carcinoma of the bladder. Such factors are the histologic appearance, the size and the extension of the tumor as well as the general condition of the patient and the radiosensitivity of the neoplasm. In addition, the technic of radiation employed and the amount of radiation energy delivered are of importance in influencing the results which may be accomplished by irradiation therapy.

Results in 160 cases in which carcinoma of the bladder was treated by external radiation from January 1938 through December 1941 are reported. There were 25 cases of papillary carcinoma, 91 of papillary infiltrating carcinoma and 44 of solid infiltrating carcinoma.

Various technics of external radiation were employed in the treatment of these carcinomas. If 200 kilovolts of radiation was given, two, three or four fields were treated with a daily increment varying from 100 to 400 r. If super-voltage radiation was employed, radiation was given through three or four portals with a daily increment of 100 to 300 r.

Satisfactory results were obtained in more than 50 per cent of the cases of papillary and papillary infiltrating carcinoma. In 13 of these cases the tumor disappeared entirely after external radiation alone. In 44 cases great regression in the size and number of the lesions was obtained. This rendered the tumor suitable for subsequent transurethral treatment. In 24 cases, regression was only temporary. No response from external radiation was obtained in 35 cases of papillary carcinoma.

Of the 44 cases of solid infiltrating carcinoma a favorable end result was obtained in only 1 case. In the remaining 43 cases, the response to irradiation was unsatisfactory. It was concluded that no more than palliation may be accomplished by external radiation in cases of solid infiltrating

38. Herger, C. C., and Sauer, H. R.: A Consideration of the Response of Bladder Tumors to External Radiation, *J. Urol.* 50:310-321 (Sept.) 1943.

carcinoma. This tumor is radioresistant and is best treated by interstitial radiation or by surgical procedures.

Tremblay, Crane and Harris<sup>39</sup> report a case of malignant osteogenic tumor of the bladder showing histologic, histochemical and chemical features of an osteogenic sarcoma. Eight other cases of primary malignant osteogenic tumor of the bladder have been reported in the literature. This type of tumor is believed to originate from remnants of the wolffian body.

Hirsch and Gasser<sup>40</sup> report a case of extramural rhabdomyosarcoma in the tissues behind the trigone and prostatic urethra of the urinary bladder in a boy aged 5 years. The position of this type of tumor favors the conclusion that it usually occurs primarily in the prostate gland; however, it may occur along the vas deferens.

Khoury and Speer<sup>41</sup> say that 8 cases of rhabdomyosarcoma of the bladder have been reported in the literature. They have added another case. The growth was situated at the trigone. The tumor grew slowly, surrounded the urethra, infiltrated the vesical wall, prostate gland and verumontanum and produced obstruction of the urethra. This resulted in hydronephrosis, ascending infection of the urinary tract and formation of a urachal fistula. The therapeutic procedures were as follows: total cystectomy and abdominal ureterostomy followed by two stage, bilateral ureterosigmoidostomy. Death occurred two and one-half months after the ureterosigmoidostomy, due to ascending infection of the urinary tract.

**Stone.**—Lepreau and Jenkins<sup>42</sup> report a case of a large vesical calculus. The patient, a man aged 34 years, had had considerable vesical difficulty and had lost 23 pounds (10.4 Kg.). On physical examination a stony, hard, rounded abdominal mass was found. Roentgenologic examination revealed an extremely large area of calcification in the region of the bladder. A suprapubic incision was made. A large friable calculus was removed, with the aid of an obstetric forceps. The patient recovered completely. The

calculus weighed 2½ pounds (1,134 Gm.) was composed of phosphates and carbonate.

A review of the literature reveals that the largest vesical calculus removed with survival the patient was reported by Smith. This weighed 2 pounds and 6½ ounces (1,084 Gm.). In this report no follow-up data were included. Randall removed a vesical calculus that weighed 4 pounds (1,800 Gm.). The patient died twelve hours after the operation. This is the largest vesical calculus that has been removed with life.

**Cystitis.**—Pool and Rives<sup>43</sup> discuss the treatment of interstitial cystitis with silver nitrate. A urethral catheter is inserted, and the contents of the bladder are evacuated. The bladder is irrigated with a saturated solution of silver nitrate. Then 30 to 60 cc. of a 1:5,000 solution of silver nitrate is instilled into the bladder and permitted to remain for three or four minutes if it does not cause intolerable irritation. At the end of this period, the solution is permitted to run out through the catheter, which is then withdrawn. The patient usually experiences severe dysuria and vesical irritability for two or three hours. Treatments are repeated daily unless a severe reaction occurs; in this case they are repeated every other day. For subsequent treatments the concentration of silver nitrate in solution is increased to 1:2,500, 1:1,000, 1:500, 1:400, 1:200 and finally 1:100. If at any time, the reaction is too severe, the concentration is increased more slowly. The results of this treatment were satisfactory in all but 34 cases.

In a year and a half, 153 cases of interstitial cystitis were observed at the Mayo Clinic. In 108 of these cases the diagnosis was made by cystoscopic examination. In 68 of the 153 cases the patients did not remain at the clinic for treatment. In 74 of the remaining 85 cases silver nitrate was employed. In 11 of the cases, treatment consisted of overdistention of the bladder while the patients were under anesthesia.

In 9 (12 per cent) of the 74 cases the patients were men and in 65 (88 per cent) they were women. The youngest patient was 22 years of age, and the average age was 51.5 years. The average duration of the disease before the patients came to the clinic was six and two-tenths years, which indicates that it has a tendency to become chronic. In 1 case, the disease had been present for twenty years. In 67 of the 74 cases the patients had had one or more attacks before

39. Tremblay, R. G.; Crane, A. R., and Harris, A.: Primary Osteogenic Sarcoma of Bladder, *J. Urol.* 51: 143-148 (Feb.) 1944.

40. Hirsch, E. F., and Gasser, G. W.: Extramural Rhabdomyosarcoma of the Neck of the Urinary Bladder, *J. Urol.* 51:517-519 (May) 1944.

41. Khoury, E. N., and Speer, F. D.: Rhabdomyosarcoma of the Urinary Bladder: A Clinico-Pathological Case Report with a Review of the Literature, Including a Tabulation of Rhabdomyosarcoma of Prostate, *J. Urol.* 51:505-516 (May) 1944.

42. Lepreau, F. J., Jr., and Jenkins, R. H.: Instrumental Removal of a Two-and-a-Half-Pound Bladder Calculus, with Recovery, *New England J. Med.* 229: 937-938 (Dec. 16) 1943.

43. Pool, T. L., and Rives, H. F.: Interstitial Cystitis: Treatment with Silver Nitrate, *J. Urol.* 51: 520-525 (May) 1944.

they came to the clinic; this indicates that various types of therapy must have been employed.

Analysis of a specimen of urine obtained by catheterization revealed pyuria in 43 of the 74 cases. The grade of pyuria, on the basis of 1 to 4, was as follows: grade 1 in 37 cases, grade 2 in 4 cases, grade 3 in 1 case and grade 4 in 1 case. Bacterial culture of the urine was positive in only 1 of the 74 cases.

The severity of symptoms, which was graded on a basis of 1 to 4, was as follows: grade 1 in 14 cases, grade 2 in 23 cases, grade 3 in 40 cases and grade 4 in 7 cases. When the patients were first observed at the clinic the capacity of the bladder ranged from 50 to 600 cc. The average capacity was 151.5 cc.

In all of the 74 cases, silver nitrate was employed, according to the technic previously described. The average duration of treatment was fourteen and two-tenths days. In several cases the patients were advised to have their family physician continue this treatment after they returned to their homes. In 66 cases, silver nitrate was the only type of therapy employed.

In 8 cases, silver nitrate failed to relieve the symptoms and overdistention of the bladder was employed subsequently.

The immediate results of treatment with silver nitrate were classified as follows: excellent in 31 cases (70 per cent), good in 14 cases (19 per cent) and poor in 8 cases (11 per cent). The results were considered excellent if the patient had been relieved of pain and did not have to urinate oftener than once during the night or more than three or four times during the day. In 31 of the 74 cases, cystoscopy was performed at the completion of treatment with silver nitrate at the clinic. In 5 there was no change in the cystoscopic appearance although the symptoms had been alleviated. In 18 the treatment produced great improvement, which was characterized by diminution of pain, decrease in the number and size of the lesions and increase in the residual capacity. In 8 there was no cystoscopic evidence of interstitial cystitis after the completion of one course of treatment with silver nitrate.

In 70 of the 74 cases, follow-up data were obtained for from three and five-tenths to twenty months after the patients had been dismissed from the clinic. In 29 of the 70 cases, the patients had not had any recurrence of the previous symptoms, but some symptoms had recurred in 41 cases. In many of these cases, the symptoms were not so severe as they had been previously; in other cases, the symptoms were just as severe as they had been previously but they responded to another course of treatment with silver nitrate.

Pool and Rives express the opinion that in many cases the disease will respond permanently to the second or even the third course of treatment with silver nitrate. Forty-eight of the patients underwent further treatment either because they had been advised to do so or because of a recurrence of symptoms. The duration of the relief of symptoms varied from one to twenty-one months, and the average was seven and six-tenths months.

Pool and Rives concluded that interstitial cystitis is a poorly understood urologic entity, and its presence often is not recognized. Its manifestations frequently are bizarre, and patients who have the disease often are classified as neurotic. Treatment with silver nitrate has been as satisfactory, or more satisfactory, than any other type of treatment which they have employed. It is economical and convenient and does not require the use of anesthesia. In cases in which the bladder is extremely irritable, it may be necessary to employ overdistention of the bladder before starting treatment with silver nitrate. So far as they have been able to determine, there are no contraindications to this type of treatment. The treatment can be carried out easily by the general practitioner, and it will enable him to cooperate with the urologist in the treatment of this disease.

*Fistula.*—Willan and Shaw<sup>44</sup> report a case of uterovesical fistula. The fistula apparently occurred after the use of radium in the treatment of metrorrhagia. An opening occurred between the base of the bladder and the cervical canal. In reported cases of vesicovaginal fistula, as in this case, a considerable time elapsed between the use of radium and the establishment of a fistula. Two operations were required before closure of the fistula was effected: first, a combined intravesical and intraperitoneal operation and, second, an intravesical operation. At the time of this report the patient had full control of urination when in bed and she had not wet the bed since the fistula was closed. During the day when sitting she also had full control of micturition, but while she was standing or walking control was as yet incomplete. Treatment of the vesical sphincters with the faradic current has helped and is being continued.

*Obstruction of the Vesical Neck.*—Hyams and Weinberg<sup>45</sup> report a study of hyperplastic change at the vesical neck in the female, based on a review of the embryology, a study of post-mortem material and a clinical investigation of

44. Willan, R. J., and Shaw, A. F. B.: A Case of Utero-Vesical Fistula, *Brit. J. Surg.* **31**:494-496 (April) 1944.

45. Hyams, J. A., and Weinberg, S. R.: Hyperplastic Change at the Vesical Neck in the Female, *J. Urol.* **51**:149-161 (Feb.) 1944.



the female urethra. In isolated cases, periurethral tubules and a female prostate may be found, but they are without clinical significance. The most constant pathologic finding in the female urethra is cystic degeneration. Inflammation, if present, tends to become chronic and is difficult to eradicate because of the presence of these cysts in the transitional epithelium of the urethra. Hyperplastic change at the vesical neck in the female is relatively frequent. Its presence is associated with severe urinary disturbance and pain. Diagnosis is based on careful urethro-cystoscopic examination.

Nesbit<sup>46</sup> states that congenital valves of the prostatic urethra are best removed by trans-urethral methods. Existing instruments which have been specially designed for the removal of these lesions cannot be safely employed in the majority of cases, and in many infants they cannot be introduced at all. Perineal urethrotomy allows the safe employment of instruments that are standard equipment of all modern urologists, namely, the McCarthy panendoscope, the high frequency generator and the Bugbee electrode. Nesbit reports a case which emphasizes that perineal urethrotomy does not preclude subsequent operation.

*Urinary Retention.*—Coller and Eastman<sup>47</sup> studied the motor activity and the thermal sensation of the bladder in 22 unselected cases before and after operation for carcinoma of the rectum.

Preoperative cystometrograms indicated a great variation in vesical capacity and intravesical pressure in cases in which the vesical function was normal. A comparison of preoperative and postoperative cystometrograms disclosed no evidence of injury of nerves governing vesical function. The cause of the temporary urinary retention which developed in 5 cases is not known; certain possible causative factors are mentioned and methods suggested for their further elucidation. After drainage with an indwelling catheter for forty-eight hours, oral administration of 1.5 Gm. of sulfadiazine daily did not prevent development of pyuria and bacteriuria. Abdominoperineal resection of the rectum destroys neither the autonomic nor the somatic nerve supply to the bladder. In view of these facts, it is probable that postoperative urinary retention after this operation, as after some other operations, such as hemorrhoidectomy, is due to local trauma and reflex inhibition.

46. Nesbit, R. M.: Congenital Valvular Obstruction of the Prostatic Urethra: Notes on Surgical Procedure. *J. Urol.* 51:167-169 (Feb.) 1944.

47. Coller, F. A., and Eastman, P. F.: Urinary Retention Following the Combined Abdomino-Perineal Resection. *Surgery* 14:223-228 (Aug.) 1943.

*Lymphatics.*—Powell<sup>48</sup> states that a study of the lymphatics of the urinary bladder indicates that a thorough knowledge of this system has definite clinical importance. This anatomical feature should be studied not only by the urologist but by any surgeon who operates on the lower part of the abdomen or pelvic organs particularly of the female.

The lymphatic network begins in the mucosa where the tiny ducts run directly to the external surface and there join large collectors containing valves. The valved collectors determine the direction in which the lymph flows. Retrograde and collateral circulation may occasionally be more difficult in these beaded (valved) vessels, which often form the main trunks. As a general rule, the lymph system of the anterior wall of the bladder is drained by collectors on each side of the midline which fuse and form a large beaded vessel. These run down along the course of the obliterated hypogastric vessel on each side toward the neck of the bladder at the origin of the ureter. There they turn later after receiving trunks from the posterior wall to join primary lymph nodes.

There is relatively little anastomosis of lymph vessels on one side of the median line with those on the opposite side.

There is a large network of small (unbeaded) lymph ducts completely surrounding the neck of the bladder, which are intimately connected with those of the posterior wall of this organ as well as with those of the uterine cervix. The collectors of the posterior vesical wall, unlike those of the anterior wall, usually leave the bladder separately to course to the regional lymph nodes. Over the floor, or the posterior wall, of the bladder there is abundant anastomosis of the lymphatic network of one side of the median line with that of the opposite side. The posterior abdominal lymph nodes receive the lymph from the bladder and other pelvic organs.

*Cystometry.*—Weyrauch, Lucia, and Howard<sup>49</sup> present statistical and clinical data which cast serious doubt on the value of cystometry as a diagnostic test. The following sources of error are discussed: (1) the great variability of cystometrograms for the three types of bladders—normal, hypertonic and atonic; (2) the inability to distinguish one group from another on the basis of either the slope of the curve or the critical end points; (3) the

48. Powell, T. O.: Studies in the Lymphatics of the Female Urinary Bladder. *Surg., Gynec. & Obst.* 78:605-609 (June) 1944.

49. Weyrauch, H. M.; Lucia, E. L., and Howard, J.: The Failure of the Cystometrogram as a Diagnostic Test. *J. Urol.* 51:191-209 (Feb.) 1944.

broad overlapping of the pathologic and the normal curves, and (4) the fact that numerous abnormal conditions produce identical changes in the curve.

Cystoscopic examination is far more reliable than cystometrography for distinguishing a neurogenic lesion from an obstructive lesion of the bladder, although this is the outstanding clinical use for which cystometrography has been advocated. Kymographic recordings of the waves of vesical contraction impart slightly more information than do curves obtained with the mercury manometer, but in most respects this newer method is subject to the same inconsistencies as the older procedure. The worth of and the need for the kymograph in the identification of various types of neurogenic bladder are doubted. Conclusions reached from a statistical evaluation of cystometrography have corroborated a clinical distrust of this biologic test. While discrediting its value as a diagnostic aid, the authors recognize that it has been of aid in studying both the normal and the pathologic urinary bladder.

#### PROSTATE GLAND

*Hypertrophy.*—Lazarus<sup>50</sup> discusses methods of treatment employed in certain cases of prostatism in which the patients are poor risks. The procedure advocated consists of suprapubic cystostomy performed through a small midline suprapubic incision, followed, after a prolonged period of drainage, by transurethral resection.

This two stage operation is particularly applicable in the following groups of cases: (1) cases of acute urinary obstruction with azotemia, in which a urethral catheter or cystoscope cannot be introduced; (2) cases of severe azotemia associated with fever due to pyelonephritis; (3) cases of severe urinary retention of long standing without azotemia, in which the patients are poor risks; (4) cases of carcinoma of the prostate with renal insufficiency; (5) cases of prostatism complicated by vesical calculi, diverticulums and vesical tumors, and (6) cases in which there are hemorrhagic tendencies.

The advantages of this two stage procedure are: 1. There is an opportunity to institute immediate and adequate drainage of the bladder and at the same time to promote rehabilitation and stabilization of renal function. 2. A suprapubic tube is less likely to cause infection and sepsis than a urethral catheter, especially when prolonged drainage is indicated, as it is for many patients who are poor risks. 3. It enables one to explore

bladders digitally for stones and to ascertain the physical characteristics of the obstructing prostate in cases in which preoperative cystoscopy cannot be performed. 4. It permits one to deal adequately with complicating factors such as vesical calculi, vesical diverticulums and vesical tumors. 5. The small incision in the abdominal and vesical walls minimizes the risk of postoperative infection and herniation, decreases the incidence of urinary leakage around drains, enables patients to be out of bed on the third day after operation and greatly facilitates closure of suprapubic wounds after withdrawal of suprapubic drainage tubes. 6. Prolonged suprapubic drainage causes extensive shrinkage and devascularization of the prostate gland and makes it readily amenable, at the proper time, to electrical resection with reduced risk of immediate and later postoperative hemorrhage and infection. 7. It offers an ideal method for through and through irrigation of the bladder following resection. 8. It greatly reduces the time of hospitalization following the second stage of the operation as compared with prostatic enucleation.

Antonio<sup>51</sup> says that treatment of hypertrophy of the prostate gland is usually complicated by the presence of other degenerative diseases and frequently by coronary heart disease. The rapid reduction of blood pressure in the course of a surgical procedure provides an ideal situation for the already impaired coronary artery to be completely occluded. The maintenance of an approximately uniform blood pressure is, therefore, of utmost importance. Excellent results were obtained in 5 cases of prostatic hypertrophy with complicating coronary heart disease in which transurethral prostatic resection was performed with the patient under low continuous spinal anesthesia. The average fall of blood pressure was only 10 mm. of mercury. The operations were uneventful. Antonio says that the combination of low continuous spinal anesthesia and transurethral prostatic resection is safe and dependable for treatment of prostatic hypertrophy complicated by coronary heart disease.

*Carcinoma.*—Wilhelmi<sup>52</sup> states that the serum acid phosphatase level is of no value for early diagnosis of prostatic carcinoma and that a normal standardized ratio must be recorded before the test is of definite value to the surgeon. The value of the urinary acid phosphatase appears to

50. Lazarus, J. A.: Suprapubic Cystostomy Preliminary to Transurethral Resection in Selected Cases of Prostatism. *J. Urol.* 51:404-410 (April) 1944.

51. Antonio, D., Jr.: The Operative Management of Hypertrophy of the Prostate with Complicating Coronary Heart Disease. *J. Urol.* 50:344-354 (Sept.) 1943.

52. Wilhelmi, O. J.: Carcinoma of the Prostate. *J. Urol.* 50:341-343 (Sept.) 1943.

be more accurate and more constant than that of the serum acid phosphatase. Orchiectomy is an advisable prophylactic procedure in all cases of early prostatic carcinoma and in cases in which this lesion is suspected.

#### TESTES

*Polyorchism.*—Handley and Crawford<sup>53</sup> report a case of polyorchism in a normally developed young man. Both testes and spermatic cords were normal except for a firm smooth mobile mass  $\frac{3}{4}$  inch (1.9 cm.) in length and attached to the upper pole of the right epididymis.

An inguinoscrotal incision, 1 inch (2.5 cm.) long, was made and the cord pulled upward. The tumor was felt within the cord at the upper pole of the epididymis and was easily shelled out of areolar tissue without opening the tunica vaginalis. The tumor measured 2 by 1 cm. Its outer surface was smooth and white, and small venules were stretched across it. A narrow white band divided the cut surface into a smaller upper and a larger lower part, both of which were pale yellow. Microscopic examination showed a miniature testis. There was a well formed tunica albuginea but no tunica vaginalis. A body and an epididymis were present. The seminiferous tubules showed an attempt at spermatogenesis; in some places this had reached the spermatid stage. Other areas showed hypoplasia similar to that seen in incompletely descended testes. Interstitial cells were present in normal proportions. The tubules of the epididymis were normal.

In 1933, Boggon found in the literature reports of only 11 cases of histologically proved polyorchism. He reported another case at that time. It seems that a single vas usually serves the double testis, but there may be a double vas. The extra testis usually is on the left side, and it may show spermatogenesis. In the case reported by Boggon, operation was performed on account of torsion. Histologic examination did not reveal spermatogenesis. In 1896, Lamb collected reports of 23 cases and found that, in addition to the extra testis, there also was an extra excretory apparatus. In none of these cases was the diagnosis proved histologically.

*Cryptorchism.*—Abrahamson<sup>54</sup> says that the incidence of cryptorchism is high among men examined for military service. Orchiopexy for cryptorchism was first reported by Rosenmerkel. Bevan described a procedure in which the sper-

matic vessels are divided to allow the testis enter the scrotum. Ombredanne brought testis through the scrotal raphe so that testes were in the same compartment of scrotal sac. Cabot and Nesbit reviewed various methods of placing traction on the testis and used elastic traction to lengthen the spermatic cord and retain the testis in the scrotum. Multiple stage procedures for abdominal cryptorchism were described and used successfully by Cabot. Torek suggested fixation of the testis into the thigh. This procedure has been extensively used by several surgeons. Several surgeons have sutured the gubernaculum to the fascia of the thigh.

Abrahamson describes an operative procedure adapted to the surgical problems involved in cryptorchism, with the added physiologic benefit of preserving the function of the testis.

An inguinal incision adequate to expose both the internal inguinal ring and the neck of the scrotum is made. This must be varied according to the position of the testis.

The hernial sac is isolated and liberated from the structures of the spermatic cord. The gubernaculum is isolated and left attached; the sac is liberated and cut across near the testis. The proximal portion is ligated. The distal segment of the sac is incised longitudinally and everted so as to envelop and protect the cord and testis. It is closed loosely with a running suture. The adhesions between the vessels and the cord, especially those about the internal ring and to the peritoneum, are freed. By following the vessels directly upward, retroperitoneally, with blunt and sharp dissection, and separating all adhesions, the vessels are liberated to allow the use of their greatest length.

The scrotal sac is enlarged by manual dilatation, to make a bed for the testis. An incision is made  $1\frac{1}{2}$  inches (3.8 cm.) long at the lateral inferior aspect of the scrotum. The gubernaculum testis is then grasped, and the testis is pulled down through the scrotal incision. The distance between the adjacent thigh and testis is measured.

At a corresponding level on the adjacent thigh and within reach of and close to the scrotal incision, an oblique incision from above downward and mesially,  $1\frac{1}{2}$  inches (3.8 cm.) long, is made, and the fascia of the thigh is exposed by retracting the lateral margin of this incision.

A flap, 1 inch (2.5 cm.) wide, is cut from the lateral aspect of the exposed fascia and reflected medially toward the scrotum. It is important to cut and reflect this flap at such an angle that it points toward the testis so that it is not twisted at its base. When the fascial flap has been ad-

53. Handley, R. S., and Crawford, T.: A Case of Polyorchidism. *Brit. J. Surg.* 31:300-301 (Jan.) 1944.

54. Abrahamson, R. H.: Operative Technique for Cryptorchidism. *J. Urol.* 51:301-314 (March) 1944.

justed in length and direction to the position of the testis and gubernaculum, the posterior lip of the scrotal incision is sutured to the medial lip of the incision in the thigh with interrupted sutures.

If the testis can be brought down to within  $1\frac{1}{2}$  inches (3.8 cm.) of the thigh, the fascial flap is reflected back toward the testis and two sutures are placed between the edge of the fascia and the tunica albuginea of the testis. The entire gubernaculum is then placed on the surface of the reflected fascia and attached by two or three carefully placed sutures.

If the testis cannot be brought down within  $1\frac{1}{2}$  inches (3.8 cm.) of the thigh without undue tension and if the intervening distance is  $1\frac{1}{2}$  to 3 inches (3.8 cm. to 7.6 cm.), the available gubernaculum (only) is placed on the reflected surface of the fascia and sutured to it at whatever point they meet. No sutures are placed between the fascia and the tunica albuginea.

The anterior lip of the scrotal incision is then sutured to the lateral lip of the incision in the thigh, and if right angle incisions were necessary they are closed with interrupted sutures. The scrotum now completely surrounds the anastomosis of the fascia to the gubernaculum and the fascial flap. The wound is dusted with sulfanilamide powder and dressed with petrolatum gauze.

Hernioplasty without transplantation of the cord is now effected by two or three sutures, to bring the conjoined tendon and the internal oblique muscle to the shelving edge of Poupart's ligament. The external oblique muscle is closed with a running suture.

The second stage of this procedure is done two to six months later (whenever the testis lies free in the scrotum). It consists of incising the skin and fascial flap through the skin of the thigh, leaving the skin of the scrotum intact and suturing the wound.

The advantages of these procedures are as follows: The spermatic cord is kept under constant tension, which increases its length and prevents retraction of the testis. No foreign material is used for traction, and the fascia used is always available. In cases in which it is not possible to lengthen the cord sufficiently to bring the testis into the thigh, the fascial flap is measured to bridge this gap. The testis remains in the scrotum, its normal position, and is allowed to develop immediately on completion of the first stage (its sensitivity to changes in temperature when it is out of the scrotum is known). The second stage is a simple procedure and does not endanger the testis. If hormonal therapy is indi-

cated, it can be instituted immediately after the first stage, with the testis in its normal habitat.

Reasons for operative intervention for cryptorchism are as follows: 1. To introduce the testis into the scrotum. After puberty, this is the only site in which the testis will produce both internal and external secretions, normal in amount and character. Consequent atrophy, sterility and lack of development of secondary sex characteristics are prevented. 2. To prevent traumatic derangements of the testis. 3. To prevent the growth of malignant lesions of the testis, which occur more frequently when it is in an abnormal position. 4. To effect cosmetic improvement.

*Tumor.*—Kleiman<sup>55</sup> says that tumors of the testis are relatively uncommon and more than 95 per cent of such tumors are malignant. He reports a case in which a man, aged 51 years, complained of enlargement of the scrotal contents. The contents of the left side of the scrotum were three times their normal size. Roentgen therapy caused the scrotal mass to shrink to less than half of its former size. Three weeks later, orchiectomy was performed. A pathologic diagnosis of hemangioma cavernosum was made.

Gilbert<sup>56</sup> reports a case of carcinoma of an atrophic right testis. The atrophy was caused by orchitis due to bilateral mumps which had occurred sixteen years previously. The patient had been sterile since that time. A review of approximately 5,500 cases of tumor of the testis reported in the literature reveals that orchitis due to mumps has occurred in 24 cases. In 3 of the cases bilateral tumors developed after the orchitis. Brief reference is made to Schoenfeld and Beebe's study concerning the size of testes at various ages and of the use of models for clinical comparison.

The average age of the patients in the 24 cases was 35 years and the average interval between the orchitis and the development of the tumor was approximately twelve years. There was a history of trauma in 4 cases. The following types of tumor were encountered: unicellular (seminoma) in 13 cases; teratoid in 9 cases, and miscellaneous in 2 cases. One patient with a unicellular tumor lived seven years after operation, but only 1 with teratoma survived five years.

It appears from this collective survey that there is no direct relationship between orchitis

55. Kleiman, A. H.: Hemangioma of the Testis, *J. Urol.* **51**:548-550 (May) 1944.

56. Gilbert, J. B.: Tumors of Testis Following Mumps Orchitis, *J. Urol.* **51**:296-300 (March) 1944.

due to mumps and the development of tumor of the testis.

#### EPIDIDYMIS

*Fibromyoma*.—Gordon-Taylor<sup>57</sup> reports a case of fibromyoma of the epididymis of an undescended testis on the right side in a man aged 42 years. The organ was of normal size; at its lower end was a firm ovoid tumor, which was painless and which was said to have been present for six months. The tumor was removed, and pathologic examination revealed that it was a fibromyoma.

Leiomyoma constitutes the most frequent variety of the rare group of benign growths of the epididymis; 13 cases were collected by Friedman and Grayzel (1941); in 2 of these cases bilateral tumors were present. The case reported by Gordon-Taylor is unique, as the tumor was situated in the epididymis of an undescended testis.

There usually is a history of gradual, painless increase of an intrascrotal swelling, although intermittent pain occasionally may have been noted. In some of the cases there has been an antecedent of gonorrheal epididymitis.

The tumor is most frequently situated in the lobus major or minor; it is rarely found in the corpus of the epididymis. The growth is round or ovoid, firm to stony hard, nodular and not usually tender. An associated hydrocele is said to be present in 50 per cent of the cases.

Correct diagnosis has only rarely been made preoperatively; the tumor often is regarded as a testicular neoplasm, and orchiectomy is performed. At the time of operation, the size of the tumor has varied from that of a pea to that of a mandarin orange.

#### SCROTUM

*Tumor*.—Nation and Potampa<sup>58</sup> report a case of neurofibrosarcoma of the scrotum. The patient was a man aged 71 years with a scrotal mass which caused him more inconvenience than pain. The mass was 15 by 20 cm.; it was firm and irregular but not tender. The testes lay free on the anterior aspect, and the right spermatic cord fused into the proximal part of the tumor. The entire tumor was removed, and microscopic examination revealed that it was a fibrosarcoma

or a neurofibrosarcoma. Convalescence was uneventful.

Nation and Potampa express the opinion that this growth did not arise from the cord but probably originated from tissues of the scrotum from the periosteum. In the differential diagnosis of a scrotal tumor one first should determine whether the tumor is of testicular or extratesticular origin, since one of the former origin liable to be much more malignant than one of the latter. Sarcoma is one of the most common of the extratesticular tumors; 30 to 60 per cent of these tumors are of this type. They are more common in the testicular tunics than in the spermatic cord. Scrotal tumors of extratesticular origin, such as the one reported by these authors must be dealt with as tumors of the same type would be if encountered elsewhere in the body.

#### PENIS

*Tumor*.—Wattenberg<sup>59</sup> reports a case of primary fibrosarcoma of the glans penis. No evidence of metastasis was apparent. This is the eighth case of primary fibrosarcoma of the penis to be reported and the third case in which the tumor originated in the glans penis. Amputation through the middle portion of the penis was performed.

#### URETHRA

*Diverticulum*.—Menville and Mitchell<sup>60</sup> report 11 cases of diverticulum of the female urethra. At Charity Hospital of Louisiana, in New Orleans, this lesion was found predominantly in the Negro race. The lesion is acquired in the vast majority of cases and almost invariably becomes infected. The pathognomonic sign is a fluctuating mass which empties on pressure. The treatment of choice is excision of the sac.

*Caruncle*.—Walther,<sup>61</sup> in a review of 100 cases of urethral caruncle in females, found 5 instances of unsuspected carcinoma and 2 instances of precancerous lesions in the 47 cases in which pathologic examination was carried out. A comparative consideration of the clinical aspects of urethral caruncle and urethral carcinoma make clear that little reliance can be placed on purely clinical diagnosis, because of the similarities

59. Wattenberg, C. A.: Primary Fibrosarcoma of the Penis: Review of the Literature and Report of a Case, *J. Urol.* 51:543-547 (May) 1944.

60. Menville, J. G., and Mitchell, J. D., Jr.: Diverticulum of the Female Urethra, *J. Urol.* 51:411-421 (April) 1944.

61. Walther, H. W. E.: Caruncle of the Urethra in the Female with Special Reference to the Importance of Histological Examination in the Differential Diagnosis, *J. Urol.* 50:350-353 (Sept.) 1943.

57. Gordon-Taylor, G.: A Case of Fibromyoma of the Epididymis in an Undescended Testicle, *Brit. J. Surg.* 31:146-147 (Oct.) 1943.

58. Nation, E. F., and Potampa, P. B.: Unusual Scrotal Tumor: Report of a Case of Neurofibrosarcoma, *J. Urol.* 51:174-177 (Feb.) 1944.

between these conditions. Since histologic examination is imperative in every instance of presumable urethral caruncle in order to exclude carcinoma, it is important that a method of treatment be employed which permits the securing of a specimen suitable for microscopic study. The author describes a method of electrosurgical excision which meets this criterion and which also is simple. It can be performed quickly and removes the growth completely. It results in a minimal amount of scar tissue.

#### MÜLLERIAN DUCT

*Cyst.*—Deming and Berneike<sup>62</sup> say that cysts of the deep part of the male pelvis fall into five general groups: (1) the cysts arising from the wolffian body or its ducts, (2) those arising from the müllerian ducts, (3) those which result from an obstruction of the ejaculatory ducts by enlargement of the prostatic utricle, (4) those of the seminal vesicle proper, which are thought to be due to occlusion of a diverticulum, and (5) those of inflammatory or parasitic origin.

Coppridge reports 6 cases in which massive midline cysts simulated a distended bladder and originated deep in the tissues between the bladder and the rectum. In many of these cases the cyst probably originated in the müllerian ducts. In addition, he reports a case in which a cyst undoubtedly arose from a remnant of a müllerian duct.

In the available reports of cases of cysts of the müllerian ducts, several common features are prominent. Most of the patients were between the ages of 19 and 40 years. All of the tumors were symmetric and situated in the midline. Most of them were fairly large and were palpable abdominally. None contained spermatozoa, and the descriptions of the cystic fluid suggested that in all cases it consisted of various stages of degeneration of blood. When operative removal was attempted, it was found that in all but 1 case the anterior wall of the cyst and the posterior wall of the bladder were practically one and the same structure, which made complete removal extremely difficult and in many cases impossible.

The clinical features characteristic of cysts of the müllerian ducts are: (1) A symmetric cystic mass is palpable rectally just above the prostate in the midline; (2) the prostate gland is normal and at least not directly involved in the cystic process; (3) urethrocytostomy shows only en-

croachment on the vesical lumen by an extrinsic mass and perhaps symmetric lateral displacement of both ureters; the utricle may or may not be slightly enlarged, and bloody discharge may be encountered at its orifice; (4) fluid from the cyst does not contain any spermatozoa or parasites and probably consists of only old changed blood; (5) the cutaneous reaction to echinococcus antigen is negative.

Histologically and pathologically there are other features which are characteristic of all cysts of the müllerian ducts. First, the epithelium is cuboidal or low columnar. Second, there is evidence of cystadenoma. Third, a cord of tumor tissue passes from the cyst through the prostate gland to the region of the verumontanum without affecting the adjacent prostatic tissue. Cysts of the müllerian ducts have been treated conservatively by aspiration or radically by excision. Recent literature favors complete removal of the cyst. The most successful approach has been the suprapubic one, since most of the cysts extend well up along the posterior wall of the bladder. Infrequently, the combined abdominoperineal approach may be indicated.

Deming and Berneike report a case in which a man aged 30 had bloody urethral discharge and urinary frequency. He also had a watery discharge from the rectum.

Rectal examination revealed that the prostate gland was normal in size, shape and consistency but that the lateral lobes were somewhat separated near the upper edge. From between the lobes there extended upward a tense, cystic mass, which was roughly in the midline but perhaps slightly larger on the right than on the left side. The upper limits of the cyst could not be reached, nor could it be palpated suprapubically, even on bimanual examination.

The cyst was tapped with a lumbar puncture needle, introduced through the perineum, and about 6 cc. of watery, chocolate-colored, odorless fluid was withdrawn. Eight cubic centimeters of a 40 per cent solution of skiodan was injected into the cyst. Roentgenograms and retrograde pyelograms revealed a pear-shaped retrovesical mass extending up to the dome of the bladder. It was situated roughly in the midline, although it extended farther to the right.

Cystoscopy revealed an appreciable elevation of the trigone and the base of the bladder, but the posterior urethra and the verumontanum showed only moderate vascular engorgement.

Through a midline suprapubic incision the posterior wall of the bladder was exposed by stripping away the peritoneum. Adherent to the

62. Deming, C. L., and Berneike, R. R.: Müllerian Cysts, *J. Urol.* 51:563-568 (June) 1944.

lower two thirds of the posterior wall of the bladder was a grayish blue cystic mass about the aggregate size of three hen's eggs. This was dissected away from the bladder with considerable difficulty, and its attachment was traced down to the prostate gland. Attached like two ears to the posterolateral aspects of the cyst were the two seminal vesicles; at the same points, apparently extending into the cyst, were the two vasa deferentia. The stalk of the cyst was traced down to the prostatic urethra, where its attachment was divided. The cyst was removed in toto with most of the prostate gland, both seminal vesicles and the distal 3 inches (7.6 cm.) of the vasa deferentia.

The pathologic report was as follows:

The portion of the specimen representing the prostate is traversed by a canal 7 mm. in diameter. . . . Sections of the prostate show the usual epithelial lining with ducts and acini. Sections of the large cyst wall itself show the wall to be made up of a thick layer of smooth muscle and fibrous connective tissue. It is partially lined by a flattened layer of deep blue staining epithelial cells. Diagnosis: Müllerian duct cyst, seminal vesicles, and portions of prostate and vasa deferentia.

#### PATENT URACHUS

According to Atcheson,<sup>63</sup> patent urachus may easily be confused with intra-abdominal conditions, such as acute appendicitis and cystic tumors, if a history of drainage from the umbilicus is not obtained.

In some cases, a patent urachus will change from the fistulous type to the sinus type. In the 2 cases reported by Atcheson, it was of the fistulous type, as evidenced by a history of urinary drainage in early life, but as inflammatory changes occurred the fistula sealed off and a sinus resulted.

It is almost a technical impossibility to excise the tract without opening the peritoneum, especially in those cases in which inflammation has existed. It is suggested that the peritoneum be routinely opened at a point below the umbilicus and that the attached tract and umbilicus be excised in toto.

Treatment of the infection in the tract before surgical treatment is carried out is important. Drainage and irrigation of the tract with some solution such as chloroazodin are satisfactory for the treatment of the infection.

Inflammation may have changed the structures of the urachal area to such an extent that the sections will not always reveal the lumen and epithelial lining of the tract.

63. Atcheson, D. W.: Patent Urachus with a Report of Two Additional Cases, *J. Urol.* **51**:424-430 (April) 1944.

#### UROLITHIASIS

Ezickson<sup>64</sup> discusses the relations of the urinary tract to urolithiasis on the basis of a series of 134 cases in which a history of urolithiasis. The cases were divided into two groups: Group 1 consisted of 70 (48 per cent) in which cultures of urine were positive, and group 2 consisted of 64 (48 per cent) in which cultures of urine were negative. Urolithiasis is predominantly a disease of the white race, occurring in only 4 per cent of this series of cases. There was a preponderance of males, 57 per cent of the cases. The highest age incidence was between 50 years, comprising 38 per cent of group 1 and 30 per cent of group 2. The majority of cases (65 per cent in group 1 and 56 per cent in group 2) fell in the age group 31 to 50.

There was a definite correlation between urologic operations and infections of the urinary tract. Thus, in 41 cases (64 per cent) of group 1, 66 operations on the urinary tract were performed, while in 16 (23 per cent) of group 2, 20 operations on the urinary tract were performed. It can be deduced from the high incidence of operations in group 1 that of the two groups, more definite underlying pathologic changes requiring surgical intervention were encountered in the cases in which cultures of urine were positive. Whether the infection was the cause or the effect of the urolithiasis could not be determined.

There were 3 deaths in group 1 and 1 in group 2. Of the 3 deaths in group 1, 2 were due to urologic disease and 1 to cardiovascular disease. The 1 death in group 2 was attributed to the cardiovascular system.

Stones were found during the study in 38 per cent of cases in group 1 and 34 per cent in group 2.

An analysis of the cultures showed that *Escherichia coli*, *Staphylococcus albus*, and *Streptococcus vulgaris* were the organisms most commonly found. In repeated cultures, these three organisms consistently predominated.

#### CHEMOTHERAPY

Campbell<sup>65</sup> discusses the surgical aspect of sulfapyridine anuria and stresses certain points in the treatment of this type of anuria.

The degree of ureteral impaction must be kept in mind throughout the treatment of renal complications caused by the sulfonamide drugs.

64. Ezickson, W. J.: The Relationship of Urinary Tract Infections to Urolithiasis, *J. Urol.* **51**:431 (April) 1944.

65. Campbell, J. M.: The Surgical Aspects of Sulfapyridine Anuria, *Brit. J. Surg.* **31**:226-233 (Jan.) 1944.

nature of the crystalline impaction and the consequent difficulties in catheterization vary directly with the interval that elapses from the time the gross hematuria began.

Patients who have sulfapyridine anuria should be catheterized early if they do not respond after a few hours of routine conservative measures. Also oliguria, hematuria and renal colic should be dealt with in a similar fashion if they do not respond within a short period to intravenous administration of fluids and diuretics.

The obstruction may become such that ureteral catheterization is impossible, and a renal operation may be necessary. Patients who cannot be relieved by cystoscopic methods should be treated by pyelostomy or nephrostomy. Operation on one side is adequate if the pelvic contents are fluid. In this case the likelihood is that the ureters can be catheterized in a few days after relief of the anuria, owing to the ability of the lower portions of the ureters to disengage themselves of a large amount of the crystals in a few days.

Bilateral pyelostomy or nephrostomy and decapsulation would be chosen only in cases of delayed anuria in which no secretion follows emptying of the renal pelvis.

Kirwin, Lowsley and Menning<sup>66</sup> state that pyridium (phenylazo-*a-a*-diaminopyridine monohydrochloride) has proved to be a valuable addition to the physician's weapons against infection of the urinary tract. In a significant number of cases it has been effective in reducing the amount of organized urinary sediment and especially in relieving the characteristic symptoms of urogenital infections, such as dysuria, burning, frequency and nocturia. Relief of symptoms has occurred in most instances, even when no decrease in the amount of organized urinary sediment was observed. This compound may be administered in therapeutic doses, with complete safety throughout the course of common urogenital infections.

#### GONORRHEA

Harrison, Botsford and Ross<sup>67</sup> describe their experiences with combined therapy with fever and sulfonamide drugs for resistant gonorrhea over a period of ten months. Up to the time this report was written, this has proved to be the most effective available method of treating gonococcal infection resistant to sulfonamide

compounds. A description is given of selection of patients, technic of administration of fever therapy, management after treatment and tests for cure. The results have been excellent, and 84 per cent cures (representing 252 patients), as determined by the criteria employed, were obtained among the first 300 patients treated. Four hundred and twenty-six fever treatments were given to this group of patients, and 1 death occurred as a result of combined hepatic and renal failure. No other serious complications were encountered, although there were 10 instances of transitory hepatitis, which subsided completely within two weeks after treatment. Only 10 patients who received one or more courses of treatment were not improved.

Culp, Magid and Kaplan<sup>68</sup> state that resin of podophyllum is unusually successful in producing prompt and complete disappearance of condylomata acuminata, regardless of the size, number, site or duration of the lesions. It is generally agreed that circumcision alone will not prevent occurrence or recurrence of penile lesions. This was supported by the findings in 4 cases. Resin of podophyllum may be applied locally to the lesions as a 25 per cent suspension in liquid petrolatum or as a paste composed of the powdered drug and water. Anesthesia is not required. Treatment is simple; convalescence usually is painless, and the lesions disappear within two to three days after a single application, leaving no ulceration or scarring. Repeated applications of the drug may be necessary in a few instances. Only rarely will there be any time lost from full military duty or similar physical activity.

The surrounding normal tissue usually is unaffected by the drug, but in isolated cases of extensive application under tight prepuces, some balanitis may result. Occasionally circumcision will be advisable because of chemical balanitis and secondary edema of the prepuce, but disappearance of the condylomas simplifies the surgical procedure.

The dramatic results obtained in a series of 100 cases and the simplicity of the treatment with resin of podophyllum prompted the authors to recommend more widespread use of this type of therapy.

#### HYPERTENSION

Hayes and Ashley<sup>69</sup> have performed cystoscopy on 55 patients with advanced hypertension. The patients had no particular urologic

66. Kirwin, T. J.; Lowsley, O. S., and Menning, J.: The Effects of Pyridium in Certain Urogenital Infections, *Am. J. Surg.* 62:330-335 (Dec.) 1943.

67. Harrison, J. H.; Botsford, T. W., and Ross, F. P.: The Treatment of Resistant Gonorrhea with Induced Hyperthermia Supplemented by Sulfonamide Therapy, *J. Urol.* 51:215-227 (Feb.) 1944.

68. Culp, O. S.; Magid, M. A., and Kaplan, I. W.: Podophyllin Treatment of Condylomata Acuminata, *J. Urol.* 51:655-659 (June) 1944.

69. Hayes, B. A., and Ashley, J. D.: Urological Factors Influencing Hypertension, *J. Urol.* 50:366-373 (Sept.) 1943.



symptoms and were under treatment by internists for essential hypertension. There were 22 men and 33 women in the group. Careful histories showed a high incidence of bed wetting and of chills and fever during childhood. Twenty-six of the 33 women had had a toxemia of pregnancy or a pelvic operation or both. On examination 54.5 per cent of the whole group were found to have obstructive lesions of the lower part of the urinary tract. Approximately 60 per cent had various changes in the upper part of

the urinary tract, which were commonly ascribed to back pressure. Other lesions found were renal calculi, ureteral calculi, renal cyst, polycystic disease, duplication of ureters and renal pelves and ptosis of one or both kidneys. The lesions found were sufficient in number and importance to suggest a urologic examination in all cases of hypertension, not only for the purpose of improving the condition of the urinary tract but for the purpose of eliminating the cause of the hypertension.

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